THE ENGINEER

The Machine Tool Exhibition at Olympia

DESCRIPTIVE SUPPLEMENT No. 1

THE Machine Tool and Engineering Exhibition, which opened at the Olympia yesterday, gives engineers an opportunity to see, for the first time in fourteen years, the progress which has been made in the machine tool industry, not only in this country, but also to a large extent in America and on the Continent. This exhibition, organised by the Machine Tool Trades Association, is the largest display of metal and woodworking machine tools and ancillary equipment ever to be staged in Great Britain. The exhibits occupy all three halls of Olympia—an area of nearly a quarter of a million square feet.

Even with this vast area we understand that a number of firms have found that the space allotted to them has only been just sufficient to display a carefully selected range of the machines they manufacture. Perhaps it is partly for this reason that the equipment shown upon every stand is of interest, and visitors will find no suggestion of monotony about the many and varied exhibits.

The British machine tool industry and makers of ancillary tools and equipment are well represented, and few manufacturers of note have failed to partake in the exhibition. Of no less interest are the many machines demonstrated by the representatives of a large selection of American and Continental manufacturers, and some interesting comparisons can be made of their respective equipment. One fact which does stand out, however, is that the British manufacturer, despite his many difficulties, is in no way behind his overseas competitor either in quality or design.

In this Supplement we give particulars of some of the interesting equipment to be seen upon the stands of manufacturers represented at Olympia. In a second Supplement and in the pages of accompanying issues we propose to continue our descriptions of machines on view. But there are more than two hundred exhibitors! Despite the amount of space we intend to devote to the exhibition, we cannot, without reducing our account to a catalogue, describe all that is on show, nor even mention every maker who has taken space. Where possible, we have restricted each account merely to a description of improvements or have referred only to individual details to indicate a trend of development. For the rest we have chosen for description a selection from those machines which seem to us of greater interest, in the hope that by describing them we shall be able to give engineers unable to visit Olympia some impression of the variety of tools on view.

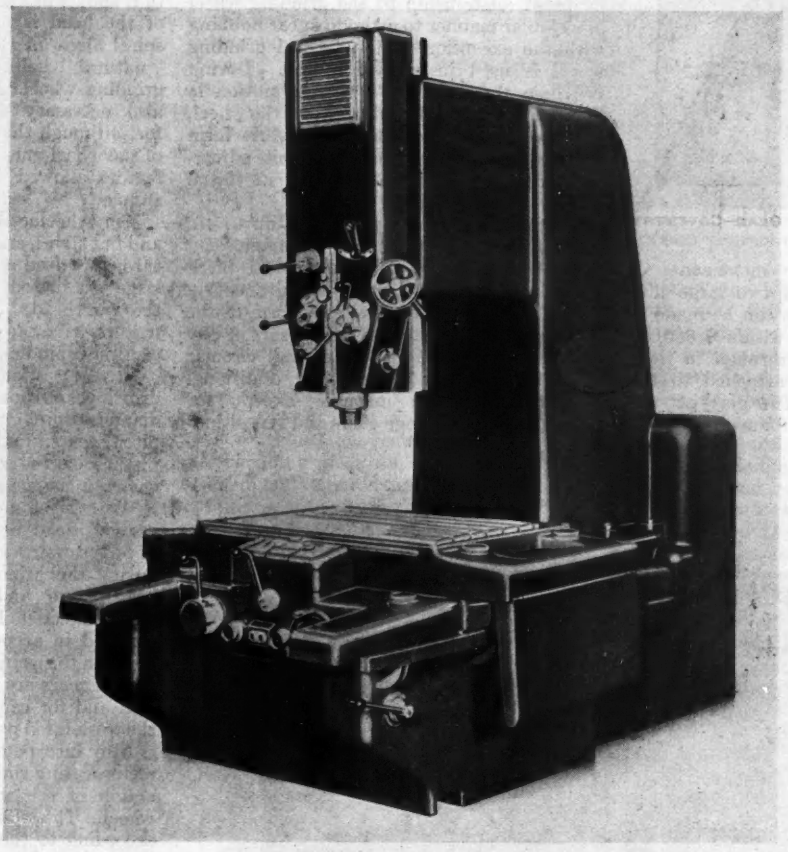


FIG. 1—"MATRIX" JIG BORING MACHINE—COVENTRY GAUGE

COVENTRY GAUGE AND TOOL COMPANY, LTD.

We are able to illustrate two noteworthy new machines which are being shown for the first time by the Coventry Gauge and Tool Company, Ltd., of Coventry.

The first of these machines is the "Matrix" No. 50 optical jig borer shown in Fig. 1. This is the first machine of its type the company has built and it is the outcome of much careful thought and investigation. For the design and construction of the optical measuring system the makers enlisted the aid of Hilger and Watts, Ltd., and in it lead screws and setting devices such as end bars have been entirely dispensed with. Glass scales, made from special high-expansion glass having the same coefficient of expansion as steel, are used in the measuring system.

In order to ensure complete rigidity the machine has been built on particularly robust lines, the castings used being of seasoned cast iron and liberally webbed. The weight of the whole frame is distributed and it is able to support particularly heavy work, both for boring and milling without distortion or loss of stability.

The spindle head, which has a vertical travel of 16in, has variable power feed between 2in and 20in per minute. It houses a large diameter quill and the spindle is carried on precision ball races. The spindle has a power travel over a distance of 8in, the feeds per revolution being variable between 0·01in and 0·001in.

A hydraulic motor is used to drive the spindle and from it power can be transmitted either directly or through back gears. The gearless direct drive gives infinitely variable speeds from 200 to 2000 r.p.m., the higher speed range making possible fine and high-speed boring with carbide or diamond-tipped tools. With a speed range of 40 to 400 r.p.m., the back gear spindle drive adapts the machine for fine milling purposes. Means are incorporated in the head for accurately measuring the travel of the quill by the use of slip gauges in conjunction with a built-in dial indicator.

The worktable has a working surface of 24in by 36in. It is mounted on compound slides, both of which can be hand or power operated and have means of rapid power traverse. For milling, infinitely variable table feed traverse rates from 0·65in to 5·84in per minute are available. The various

feed rates and directions are all controlled from a single lever operating in a gate on the front apron of the machine. A conveniently placed handwheel on this apron can be used for fine setting purposes or for hand operation of the table.

The optical measuring system enables

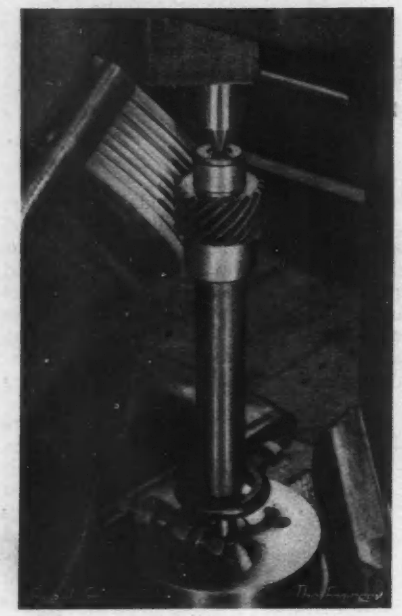


FIG. 2—GRINDING HELICAL GEAR—COVENTRY GAUGE

the lateral and transverse movements of the table to be viewed on two large illuminated scales, and settings can be made in either direction directly to within 0·0001in. Readings are projected through a lens system, from glass scales attached to the table and the base, on to two glass screens which have optical verniers for use in fine setting. The complete viewing unit is mounted at the front of the table and is protected from damage by armour plate glass. Visual external scales are situated on both slide movements for checking and setting purposes.

The complete table unit has been designed to permit the use of coolant during boring and drilling so that possible inaccuracies resulting from the local heating of the work can be avoided.

No motors or mechanism likely to generate heat or disturb the accuracy of the machine are fitted below the table. The main drive unit, including the driving motors for the spindle and the feed, is housed at the rear of the column, and stands apart from the main casting. Drive is transmitted by anti-vibration couplings, and the transmission of heat and vibration is avoided.

After much research and investigation into the problems of high precision ground gear production, the company has developed a gear-grinding machine which operates on an original principle. The machine, shown in Fig. 3, is designed to produce gears at a high rate with consistent accuracy under mass-production conditions.

The method of grinding adopted employs the fundamental principle of gear tooth development from the basic rack, which in this case is formed on the periphery of the grinding wheel, in a continuous spiral. The work is rotated continuously at a set rate in direct relationship to the grinding wheel in a similar manner to orthodox gear hobbing with the exception that a formed grinding wheel is used instead of a hob. During grinding, the work by a rolling motion is allowed to explore the full width of the wheel, and the wheel generates the involute form entirely automatically and without adjustment to the machine apart from its initial setting.

This machine grinds gear teeth up to 4in long on work up to 6in in diameter. On it batches of gears of 16 diametral pitch and finer can be ground simultaneously from the solid. The spiral rack form of the wheel makes it possible to grind gears of any diameter having similar diametral, circular or module pitches without any additional setting up of the machine except for alteration of the change gears and repositioning the wheel. Spiral gears up to 45 deg. helix can be accommodated in the machine, and spiral and spur gears of the same pitch can be ground with the same wheel without the need for redressing.

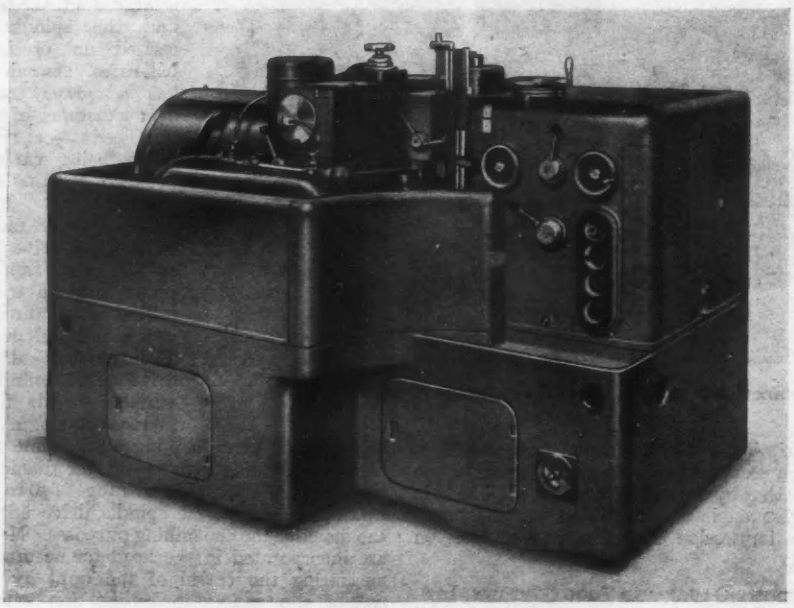


FIG. 3—GEAR GRINDING MACHINE—COVENTRY GAUGE

On the grinding wheel the spiral rib rack formation is produced in three dressing stages—rough crushing, diamond dressing and finished crushing.

The rough or primary crushing operation is carried out by an annular grooved rack form crusher, traversed across the wheel by means of a hydraulic system and cam mechanism. This crusher is housed in a unit, mounted above the grinding wheel, together with the diamond dresser, which performs the intermediate dressing stage. Two diamonds of appropriate form in this dresser are, by the same hydraulic system and cam mechanism, traversed across the wheel to prepare the roughed-out form for the final crushing stage. For the final crushing operation to finish the rack form and impart a true helix on the wheel, a helical precision-formed crushing roller is used. This roller is mounted on a simple bracket attached to the work slide.

The complete wheelhead unit, comprising the wheel, wheel spindle and electric motors, is arranged in the form of a drum, and the whole assembly can be swivelled 45 deg. to either side of the horizontal position. When setting up for grinding spiral gears, such as that shown in Fig. 2, the angle of inclination of the head is not only dependent on the spiral angle of the gear, but also upon the "natural" helix of the spiral rack of the grinding wheel. Inclination of the head is also necessary when grinding spur gears, for, although the teeth are parallel, the form of the wheel must be considered. With these factors allowed for, setting of the head is simple.

The wheelhead unit is mounted on vee and flat slides, and its movement is controlled through a feed screw and nut operated by a large graduated handwheel on the top of the workhead. Two dynamically balanced motors drive the grinding and the truing and crushing spindles.

In the automatic wheel crushing and dressing unit one cam is required for all diametral pitch gears and one for all circular pitch gears, and change over for various pitches on the wheel is made by means of enclosed change gears.

Work is mounted on a mandrel between vertical dead centres—see Fig. 2—and fed in an upward direction across the wheel during the grinding operation. The workhead drive and grinding wheelhead are interconnected by gearing which can be changed in accordance with the number of teeth on the gears being ground. Two further sets of gears are used for selecting the spiral lead and for controlling the speed at which the work is fed past the wheel.

Also incorporated in the workhead is a reciprocating slide which imparts the rolling action of the work across the face of the wheel. This slide movement can be varied, according to the size of the gear, by a sine bar setting.

Another new "Matrix" machine being exhibited for the first time is a thread miller for plastics. This machine is designed to take work up to 24in diameter over the gap, and to 18in over the bed. It has a maximum threading capacity length of 3in and takes work up to 18in long.

In addition to these machines the firm is exhibiting its well-known range of gauges, measuring instruments, &c.

BRETTS PATENT LIFTER COMPANY, LTD.

The board hammers made by Bretts Patent Lifter Company, Ltd., of Foleshill Works, Coventry, are now so well known in industry that there is little need for us to describe these exhibits in detail. Two of these hammers are shown on this firm's

stand, together with its latest designs of a 100-ton upright form press, a 10-cwt motor-driven drop hammer, and a 150 lb forging and tagging hammer.

The 1000 lb board hammer illustrated in Fig. 4 is typical of the board machines, which are now made with tup weights ranging from 300 lb to 4000 lb. It is of interest to note that these hammers are now

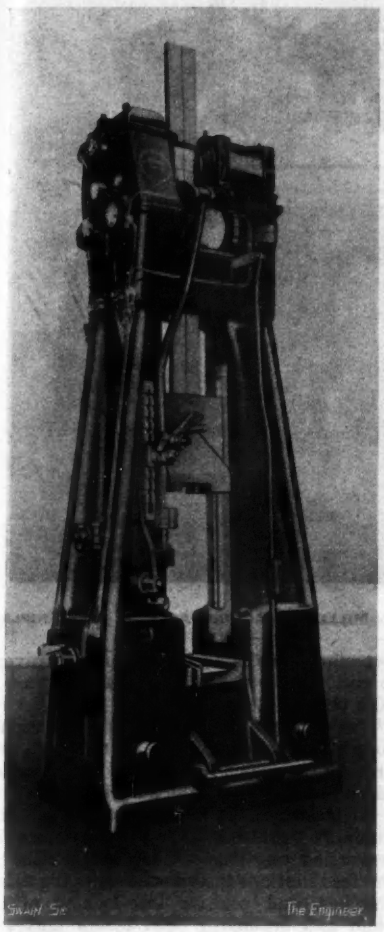


FIG. 4—1000 LB BOARD HAMMER—BRETTS

being built with hydraulic automatic operation, which enables the operator to vary the stroke of the tup at will during actual stamping. A similar type of hammer of 200 lb capacity on the stand is designed to give up to 120 blows per minute with automatic operation on its lower strokes, or single blows at will. These smaller machines are built in a range having tups from 50 lb to 200 lb, and they can be arranged for dual hand, foot or combined hand and foot control.

CHURCHILL MACHINE TOOL COMPANY, LTD.

For many years the Churchill Machine Tool Company, Ltd., of Broadheath, near Manchester, has specialised in the design and construction of grinding machines of all types and sizes, and, as might well be expected, an interesting selection of these machines is to be seen upon its stand at Olympia.

The largest exhibit is one of the firm's "Model D" traversing-table, roll-grinding machines, which is shown in operation grinding a cambered roll. On this machine all types of parallel and cambered rolls up to 20in in diameter and weighing up to 8500 lb can be ground. It is made with different length capacities, ranging from 72in to 168in, and as shown is fitted with the firm's standard cambering mechanism, "Hydrauto" wheelhead bearings and automatic lubrication to the table ways. A variable-speed wheelhead on this machine is controlled electronically from a special electric control panel.

A new automatic sizing internal grinding machine, which is illustrated in Fig. 5, is intended for precision production work. This machine is arranged to operate on a double cycle owing to the length of the bore ground—which can be up to 12in—compared with the width of the grinding wheel. The operation is thus divided into a roughing and a finishing cycle.

In operation, when the hydraulic power traverse is engaged, the table moves to the right at a speed of 35ft per minute. During this movement the truing dog depresses the truing speed throttle valve, but a mechanical interlock prevents any reduction of table speed until a second dog actuates the grinding traverse valve control lever. This lever operates a butterfly valve at the outlet to the main valve and causes a traverse speed reduction for the actual grinding operation. At the same time a link withdraws a plunger to release the drive to the automatic cycle for the sizing cam motion. The hydraulic mechanism is so arranged that as the table moves to and fro a feed lever actuating the automatic cross feed to the wheel slide spindle is oscillated. This combined movement continues until the roughing peak on the sizing cam is reached, and the slide then drops back.

Simultaneously, electrical contacts inside the feed box energise a solenoid to withdraw a plunger in the reverse lever clear of the path of the reversing dog and to allow the table to run out to the dead stop position. This completes the roughing cycle.

To start the finishing cycle the hand reverse lever is moved to the right and the table commences to run in and automatic compensating feed to the wheel slide is put on mechanically before the truing position is reached. When the truing dog depresses a roller lever to slow down the table traverse speed, a diamond truing device is swung down hydraulically to true the wheel. The table then speeds up again until the grinding dog comes into operation, when it slows down to oscillate at the grinding speed. As the grinding movement commences the automatic cam feed again comes into operation and continues until the finishing sizing peak on the cam is reached followed by a brief dwell period. The slide then drops back

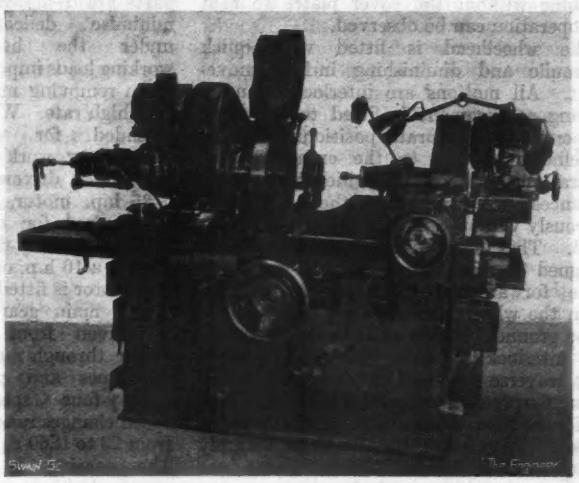


FIG. 5—AUTOMATIC INTERNAL GRINDING MACHINE—CHURCHILL

to allow the wheel to withdraw from the work, and the solenoid withdrawing the reverse plunger is re-energised to allow the table to run out to the left to the dead stop position. In this position the work rotation is stopped, the water supply cut off and the component is ready to be removed from the chuck or fixture.

As the grinding feed is entirely automatic and controlled by the contour of a cam, it is important that the wheel slide should be sensitive to the slightest variation in setting. To ensure this the wheel slide is relieved of the weight of the spindle drive and is mounted on separately ground slides with an efficient system of lubrication. The motor driving the wheel spindle is mounted on a roller slide and is connected to the wheel slide by a link bar, which allows the motor slide to follow the movement of the wheel slide

FIG. 6—CRANKPIN GRINDING MACHINE—CHURCHILL

without putting a load on it.

The workhead spindle is mounted in dual ball thrust and journal bearings and is arranged for four work speed changes through an endless vee-belt drive. A swivel base on which the workhead is carried allows for the turning of the head up to 30 deg. towards the operator.

A new high-production crankpin grinding machine shown in Fig. 6 is designed to accommodate crankshafts up to 36in long and having a maximum swing of 14in. In this machine all the mechanisms are enclosed in an apron fitted to the front of the body, and it is possible, if required, to run the machine without the cover plates so that full operation can be observed.

The wheelhead is fitted with quick hydraulic and diminishing in-feed movement. All motions are interlocked and a spacing arrangement is fitted to the table to permit the accurate positioning of the wheelhead relative to the crankpins. A central automatic steady which is provided advances and retracts from the work simultaneously with the movement of the wheelhead. The interlocking arrangements are designed so that the wheelhead can only come forward to the grinding position when the wheel is directly opposite the pin to be ground. Provision is made to modify the interlocking arrangement to give a slow traverse speed of the table for wheel truing purposes. Automatic electrical clamping for the throw blocks is designed to prevent work rotation until the crank is securely clamped in the blocks. The workheads are driven by a common shaft which ensures synchronised movement of both heads. Adequate balancing arrangements are provided with a visual check indicated by a balancing meter.

A new 10in by 36in plain grinding machine and a 12in by 36in redesigned universal grinder on this stand present a particularly clean and modern appearance. In these machines a well-arranged front panel carries the wheel feed and table mechanisms, all of which are easily accessible for servicing and maintenance purposes.

Other machines to be seen upon the stand include a thread grinder fitted with the firm's "Pulcrush" wheel-forming device, a 40in vertical-spindle surface grinder, and a centreless grinder of standard design.

ADCOCK AND SHIPLEY, LTD.

A representative selection of standard types of milling and drilling machines to be seen upon the stand of Adcock and Shipley, Ltd., Ash Street, Leicester, includes some interesting new and special-purpose machines.

Amongst the standard machines now being made by this firm is the very heavy duty milling machine which we illustrate in Fig. 8. It can be supplied as either a plain or a universal type and is specially designed and built for use with tungsten carbide and negative rake cutters. All of its component parts are designed to minimise deflection under the heavy working loads imposed when removing metal at a high rate. When intended for very heavy-duty work the machine is driven by a 25 h.p. motor, but if required for only normal heavy-duty milling a 10 h.p. or 15 h.p. motor is fitted.

The main gearbox is driven from the motor through multi-vee ropes and gives twenty-four spindle speed changes ranging from 23 to 1260 r.p.m. The gearing is so arranged that even when using carbide cutters at high cutting speeds the diameter of the largest size cutter to be used is less than that of the final drive gear wheel. This arrangement is stated to eliminate chatter likely to be caused by tooth deflection and torsional vibration. A particularly large and heavy final drive wheel situated immediately behind the spindle nose bearing acts as an effective fly-wheel when milling with carbide cutters. An additional centre bearing, which has for a number of years been a feature of several types of milling machines made by this firm, considerably increases the rigidity of the spindle.

The work table, which is 72in long by 17in wide, is provided with an infinitely variable rate of feed change to give the table a stepless range of longitudinal and transverse feeds from $\frac{7}{16}$in to 63in per minute. Means of rapid power traverse are incorporated by which the table can be moved in either direction at a rate of 150in per minute. The vertical rate of table feed is also infinitely variable between $\frac{1}{4}$in and 16in per minute and under rapid power traverse it can be raised or lowered at a speed of 40in per minute.

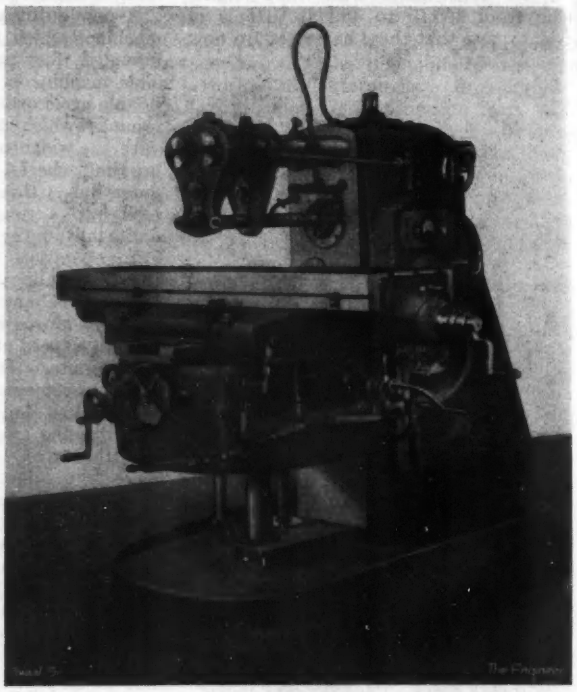


FIG. 8—HEAVY DUTY MILLING MACHINE—ADCOCK AND SHIPLEY

Twin overarms 5in in diameter are designed to support the arbor, and, if required, twin arm braces which fold down on a bracket can be supplied with the machine.

At both the front and rear of the machine duplicate controls are provided for all traversing motions. The mechanism of the feed motions incorporates slipping safety clutches, and positive interlocking of the hand and automatic feed levers makes it necessary to disengage hand feeds before automatic feeds can be engaged.

A new model of the firm's No. 1 size milling machines, with a work table 18in by 17in, which is to be seen has a fabricated base into which the switchgear is built. This machine is made in thirty-two standard models, which are obtained by different combinations of two types of columns, four speed ranges, five different designs of feed mechanism and two production feed mechanisms, one of which gives a completely automatic cycle.

We have from time to time described in the columns of THE ENGINEER special-purpose machines incorporating the unit heads made by this company. To show a typical example of this type of machine the special equipment being exhibited includes an automatic cycle unit-head machine laid out to turn, drill, tap and mill automobile valve tappets. As can be seen from the photograph reproduced in Fig. 7 the machine consists of a heavy box-section bed having one of the firm's standard unit heads at each end. These units each carry and drive a three-spindle drilling and tapping head. Mounted mid-way along the bed is a five-station work-indexing fixture. On a box column at the rear of this fixture is a third unit head which drives two milling spindles.

The arrangement is such that two com-

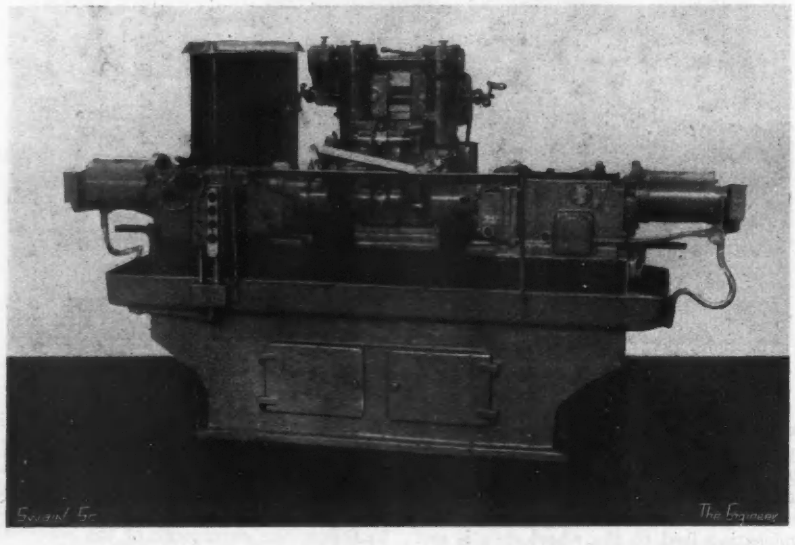


FIG. 7—AUTOMATIC CYCLE UNIT HEAD MACHINE—ADCOCK AND SHIPLEY

ponents are machined simultaneously, one on each side of the fixture. The front station of the fixture is used for loading and removing the machined components. At the four working stations the following operations

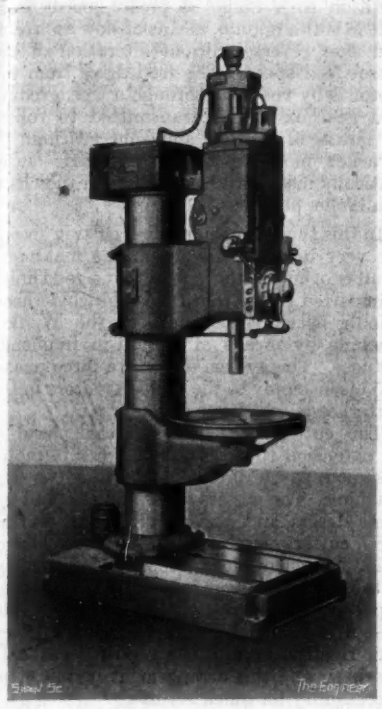


FIG. 9—28IN DRILLING MACHINE—ADCOCK AND SHIPLEY

are performed—drilling and turning the outside diameter of a boss, reaming the hole and facing the boss, tapping the hole, and, finally, milling two flats across the boss.

Each of the units is driven by a flange-mounted motor and incorporates slip gears by means of which the feed rate or time cycle can be varied. All three units are electrically interlocked for starting by a single push button. A limit switch in each unit mechanism automatically switches off the power of the individual unit as it completes its working cycle.

In the multi-spindle heads of the two side units two spindles are geared to the required drilling end turning speed, and the third, which is geared for the necessary tapping speed, is fitted with an independent automatic reversing mechanism. The two vertical cutter spindles of the milling unit can be moved along horizontal slides when it is required to alter their spacing for different lengths of work.

A drill-testing machine the company is manufacturing for the Admiralty has been designed to provide the wide range of conditions required in a research department. The machine is driven by a 3 h.p. motor and the spindle speeds available are infinitely variable between 200 and 2500 r.p.m. A special speeding unit provides an additional range of speeds up to 9000 r.p.m. Twenty-five changes of feed from 0·001in to 0·020in per revolution are available. The feed changes are obtained by moving levers and spindle speed changes are made by means of a handwheel.

The machine is generally similar to a conventional drilling machine and its fixed pedestal-type table has a compound slide on its top in order that it can be moved longitudinally and transversely to drill a number of holes in the same specimen. The spindle bracket is adjustable for height on the column face and incorporates an additional steady to give the greater rigidity required for drill testing. Above a tachometer built into the head to show the spindle speed is a wattmeter which indicates the power consumed whilst drilling.

A new 28in all-geared drilling machine, (Fig. 9) which has recently been introduced, is designed to incorporate in a sliding spindle bracket machine the rigidity usually associated with a fixed-head machine. In this machine the whole head is carried on a heavy bracket which can be moved over a distance of 15in on the machine column. A power elevating mechanism with which head adjustments are made is interlocked so that it cannot be engaged until the head is unlocked. A 5 h.p. motor mounted at the top of the head, in addition to driving the spindle and feed gearboxes, drives the head elevating mechanism.

Sixteen spindle speeds from 19 to 1360 r.p.m. are available with six rates of feed, giving from 0·004in to 0·033in per revolution. With both the hand and the power feed the length of spindle traverse is 15in. The machine is designed to drill up to 2in diameter in steel.

DRUMMOND BROTHERS, LTD.

An interesting addition to the well-known range of "Maximatic" automatic multi-tool lathes made by Drummond Brothers, Ltd., of Guildford, is a new machine known as the "Maximinor," which is now being shown publicly for the first time. This machine, as will be seen from Fig. 10, follows generally the design of the "Maximatic" lathes, but is primarily intended for producing smaller components where the use of the larger capacity machine would not be economic.

The new machine is made in three models, each of which is designed to swing up to 12in over the bed, but having distances between centres of 18in, 30in and 42in. Two types of headstock are available. One provides a speed range from 50 to 650 r.p.m., the other has a speed range from 500 to 2000 r.p.m. In the low-speed model a 5 h.p. motor is flange mounted on the rear of the headstock and is geared directly to the first speed shaft. From this shaft the drive is taken through pick-off change gears to a pinion driving the bull gear on the mandrel. A drive for the feed box is taken from the rear end of the mandrel by silent chain. The flange-mounted motor of the machine with the high-speed headstock drives the first speed shaft through bevel gears, and the drive is then taken direct to the mandrel by vee belts. The belt pulleys are mounted on the outside of the headstock and are designed for easy removal when a change of speed is required. When the machines are required for heavy-duty work a 7½ h.p. motor can be fitted.

The saddle of the machine carries one or two former-plate operated cross slides and incorporates means of quick power traverse. The former-plate carriers are located in the top face of the saddle, each former operating on a roller pin set centrally beneath the slide. The front cross slide has a stroke of 2½in and an adjustment of 2in, whilst the rear slide has a stroke of 3in with an adjustment of 2½in. Seven saddle feeds ranging from 0·003in to 0·030in per revolution are provided and on the machines exhibited the respective lengths of saddle traverse are 10in, 22in and 34in.

Visitors will see three of these machines in operation on the stand—one turning ball races, the second finish turning mandrels, and the third which is fitted with a form turning attachment engaged in turning shafts with a single-point tool.

A new heavy-duty gear-shaping machine exhibited generates gears up to 18in by ¾ D.P., and is designed for the production of spur, helical and internal gears or a wide range of non-circular shapes where accurate reproduction is required. A feature of this machine—see Fig. 11—is the setting of the work spindle in a slide carried on a heavy bed. This assembly can be swung clear of the machine on a vertical bearing to facilitate the loading and unloading of components. Another innovation is the simplified arrangement for the selection of speeds and feeds by means of handwheel selectors instead of levers.

As in all "Maxicut" gear shapers, the "generating" principle is adopted for cutting both external and internal gears. A circular gear-toothed cutter mounted on the cutter spindle reciprocates and at the same time revolves slowly as if in mesh with the gear being cut, forming gear teeth of the true involute form in the gear blank. The timing of the cutter spindle rotation with that of the work spindle is done through suitable gearing and varies with the number of teeth in the gear being cut.

The machine will cut either on the upward or the downward stroke of the cutter spindle and can be set to complete a gear in either one or two complete revolutions of the blank.

A 3 h.p. motor housed in the rear of the machine drives it through vee ropes and a gearbox. The pulleys are stepped to provide

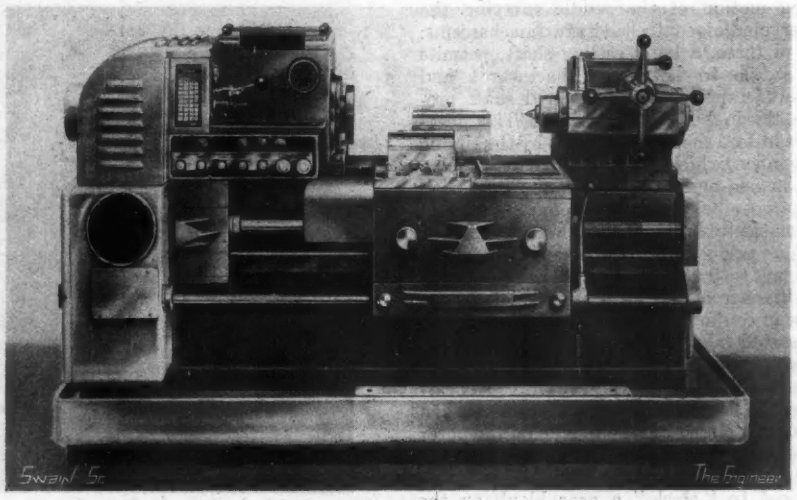


FIG. 10—"MAXIMINOR" MULTI-TOOL LATHE—DRUMMOND

two speeds and these, together with the four-speed gearbox, give a choice of eight speeds.

The rotary motion of the cutter spindle is obtained from a feed shaft carrying a worm which engages with the indexing worm wheel in the saddle. The worm wheel houses the outer guides which bear against the corresponding guides on the spindle, these guides being suitably made for the cutting of spur or helical gear teeth. The speed of cutter rotation is determined by the feed gearbox which has a choice of six feeds from

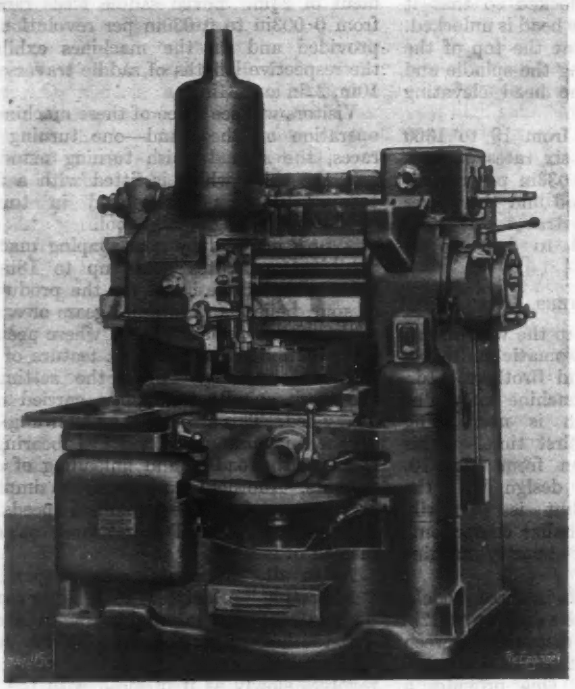


FIG. 11—GEAR SHAPING MACHINE—DRUMMOND

710 to 1740 strokes per revolution of the cutter, any one of which can be selected by turning the feed selector handwheel.

The cutter spindle reciprocating motion is obtained from a rocking shaft engaging a rack cut in the spindle. This shaft is actuated by a crank at the side of the machine, the speed of reciprocation being variable from 50 to 300 strokes per minute. The length of the stroke is adjusted on the crank mechanism, which is graduated to permit quick setting.

The motion of the saddle carrying the cutter spindle is controlled by two mechanisms. One of these, a hand setting shaft, permits the saddle to be wound backwards and forwards rapidly, and a screwed shaft provides the in-feed automatically. This automatic in-feed shaft is controlled by the timing mechanism, which can be adjusted to finish a gear in one or two cuts. Upon completion of the gear being cut a tripping mechanism automatically brings the machine to rest.

The work spindle is rotated by a worm engaging with a wormwheel beneath the slide and driven from the main shaft through change gears in conjunction with the cutter spindle. As stated above the slide base carrying the work spindle can be swung out for loading and unloading purposes and swivels on a bearing on the side column of the machine. When the slide is closed a large tongue on the outer end engages two bearing surfaces to lock the slide to the machine body. When it is required to "clock" a gear blank on the work spindle it can be rotated by a detachable handwheel on a shaft beneath the slide.

The relieving motion to the slide is obtained by a rack and quadrant which is carried on an arm actuated by push rods operated from cams in the gearbox. These cams are set to give a clearance of 0·04in between the gear being machined and the cutter on each return stroke.

WADKIN, LTD.

Sixteen machines have been selected by Wadkin, Ltd., of Green Lane Works, Leicester, to show representative types of the wide range of woodworking machinery it makes. Many of these machines are familiar to engineers, woodworking machinists, and pattern makers alike, but a machine of particular interest is the company's new four-sided planing and moulding machine to be seen in Fig. 12.

This machine is capable of planing or moulding all four sides of timber up to 4in by 4in in section at one operation, by means of four or more rotating cutterblocks, carrying either plain or shaped cutters. The timber is fed through the machine past the cutter-blocks by power-driven rollers, and controlled during its movement along the bed by a system of flexible and fixed pressure rollers and fences.

The timber is fed to the cutterblocks between four 6in diameter rollers. Two of the rollers are in the bed of the machine, and two immediately above are carried on a vertical slide with handwheel means of adjustment to allow for different thicknesses of timber. The top rollers are carried in independent swings to ensure that their angular movement relative to the bed is always constant irrespective of timber thickness. The feed rollers are driven by a 3 h.p. multi-speed motor, which in conjunction with special control arrangements gives, in addition to a range of preset speeds from 30ft to 90ft a minute, means of slow approach and slow reverse without alteration of the preset feed speed. The feed drive from the motor is by vee belts through a worm reduction gearbox and is transmitted to rollers by means of a chain and spur gearing. A sprocket mounted on an eccentric automatically maintains the tension on the chain at all roller positions.

In this type of machine high cutting speeds are very desirable to obtain the maximum number of cuts to the inch so that a good finish is imparted to the work. A high cutterhead spindle speed is obtained in the Wadkin machine by means of a built-in frequency changer. This system provides a three phase, 125 cycle supply to the built-in motors in the cutterheads, which run at 7500 r.p.m.

The cutterblock arbor on each head is an extension to the shaft of a 6 h.p. motor designed as an integral mounting on the machine. The motors and spindles are of the same design and size on all heads, and all the cutter equipment is interchangeable. The cutterblocks are mounted direct on to the spindles and are located by self-centring taper collars against a taper shank. The design of the spindle units gives the necessary rigidity without the need for outboard bearings, and this arrangement permits easy accessibility for quick set-ups.

On the horizontal cutter heads the complete spindle unit is mounted on a vertical column and arranged for adjustment along slideways through a crank handle operated elevating screw. Means of cross adjustment is incorporated in a cylindrical housing which carries each spindle unit on its cutterhead. On the side heads the spindle housing forms the slide for the vertical adjustment and a handwheel-operated slide gives cross adjustment. All adjustments are arranged for operation from the front of the machine.

The nearside head and top heads are fitted with radial spring-loaded chipbreakers which are effective for variations of up to ¼in width of stock. For variations of more

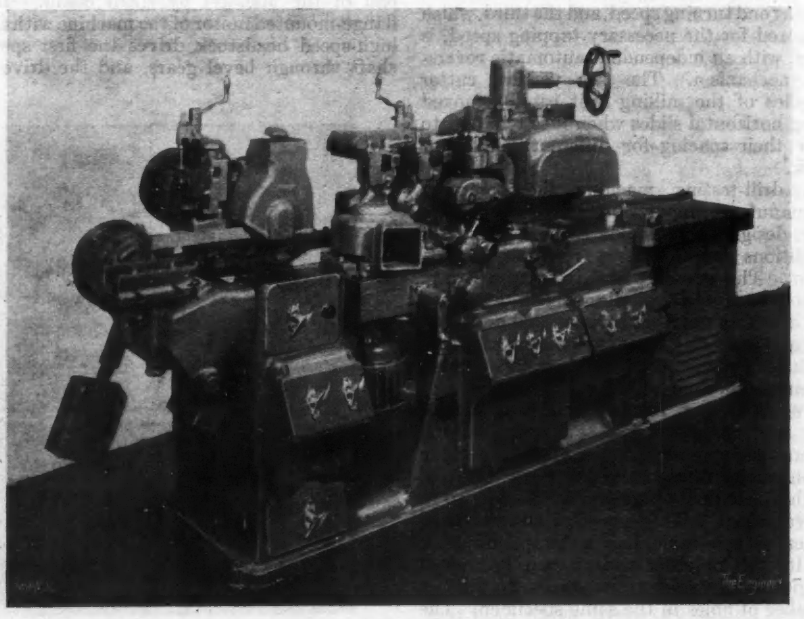


FIG. 12—PLANING AND MOULDING MACHINE—WADKIN

than this the radial mounting comes into action to clear the cutters. The chip-breakers move with the heads and are designed to swing away to give access to the blocks.

The feed mechanism, cutterheads, pressure rollers, &c., are all mounted on a one-piece bed, the table of which is fitted with renewable plates throughout its entire length. Sections of table in front of the horizontal bottom head are adjustable in respect to the cutterblock to give the minimum gap with all cutter projections. The table in front of the first bottom block also has means of vertical movement for adjustment purposes. The bed plates adjacent to the side heads are mounted telescopically and attached to the side head spindle units so that they slide laterally as the heads are moved in or out to maintain an unbroken table surface.

The electric control arrangements for the power motions embody a number of novel features. The switchgear is contained within the machine, and the control operations, apart from the master stops and the feed speed selector switch, are all carried out by means of four-position rotary switches, situated at convenient positions on the front of the machine. Provision is made in the design of the machine for exhausting the chips, chutes being cast in the main frame for exhausting from the bottom heads. Cast aluminium exhaust hoods are fitted to the remaining heads.

Also to be seen on this stand is the largest woodworking machine made by this company. It is a double-end tenoning machine, taking material up to 30in by 6in section and cutting lengths up to 8ft 6in between shoulders.

This machine—illustrated in Fig. 13—has two headstocks, the one on the right being fixed and the one on the left movable, to suit varying lengths of timber. Each headstock has two vertical columns carrying a horizontal cut-off saw, two scoring saws if required, two tenon heads, and top and bottom scribers. These headstocks also carry the top caterpillar pressure beams and the feed-chainways.

The cut-off saws are mounted directly on the motor spindles at the front of the machine headstocks. They can be canted to 45 deg. up or down and may be used above or below the work as required. Scoring saws are offered as optional equipment and can be attached to the main tenon head. The horizontal tenon heads are provided with horizontal and vertical adjustment and are arranged to cant 30 deg. up and 10 deg. down. Two cutterblocks, each 3in wide, are provided on each tenon head to ease the cut and break up the chips to facilitate exhausting. The top and bottom tenon heads can be adjusted vertically, independently, and also together.

Vertical scribing heads are independently mounted on the rear vertical column of each headstock. They are provided with vertical and horizontal adjustment and arranged to cant up to 45 deg. Each scribing spindle is powered with a 5 h.p. motor but 10 h.p. units are available for very heavy work.

The machine is provided with an overhead beam, equipped with two horizontal veeslides, to carry three adjustable gaining or trenching units each side of the beam.

The trenching unit comprises a rotor and stator spindle assembly, running at 3000 or 6000 r.p.m., depending upon the operation required. It is trunnion mounted and arranged to cant through 180 deg., so that the spindle can be used projecting to the left or right or vertically, or at any intermediate angle. Horizontal rack traverse and vertical screw traverse is provided to each head. A range of grooving heads is available for these spindles and a chuck is provided for taking parallel shank cutters when the spindle is arranged for vertical operation. By overlapping heads on the two sides of the beam and using spindle extensions to right and left, four close-centre grooves can be made.

A variable speed feed chain motor gives infinitely variable feed of 10ft to 30ft per minute. A slipping clutch is embodied in the transmission so that in the event of a jam or overload, it slips out of gear and stops the feed.

The motors are operated by rotary switches mounted on the chain beams in a convenient position for the operator and a master stop is fitted on each beam.

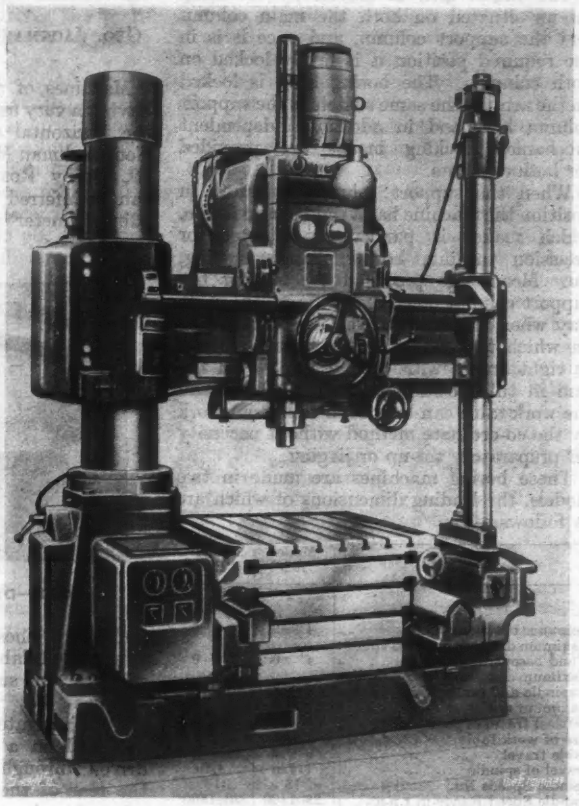


FIG. 14—RIGID BORING MACHINE NEWALL

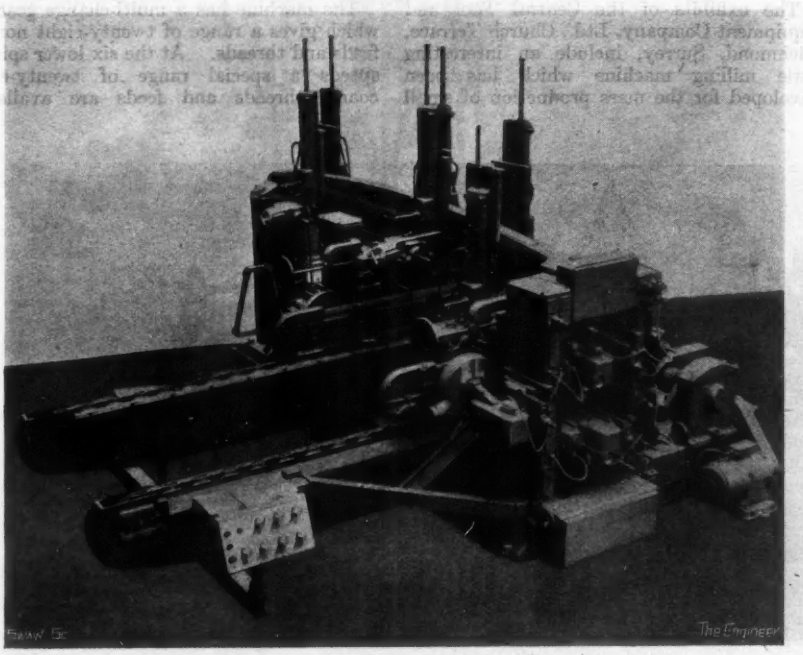


FIG. 13—DOUBLE-ENDED TENONING MACHINE—WADKIN

NEWALL ENGINEERING COMPANY, LTD.

A large range of machines is shown on the stand of the Newall Engineering Company, Ltd., of Peterborough, many of which we have already described in these columns. In addition to a number of cylindrical, internal, surface and thread grinders, the firm's three sizes of jig-boring machines, with table capacities of 18in by 12in, 36in by 24in, and 42in by 24in, occupy prominent positions among the exhibits.

The Oerlikon rigid boring machine now being made by Newall's will certainly attract attention from visitors. As can be seen from the photograph we reproduce in Fig. 14, this machine is built on the lines of a radial drill but has a supporting column at the outer end of the radial arm. This support is designed to impart rigidity to the arm and prevent any tendency

it may have to deflect under the weight of the workhead. The foot of the support column moves on curved guideways as the arm is swung and can be locked in position by an electric switch.

The radial arm is moved by elevating screws situated on both the main column and the support column, and once it is in the required position it is firmly locked on both columns. The boring head is locked on the arm by the same switch as the support column lock and in addition independent mechanical locking means are provided for both elements.

When the support column is locked in position the machine has a rigid closed frame, which makes it particularly adapted for precision turning, boring, flange turning, &c. Means are provided for locking the support column precisely in the centre of its way when the arm and the transverse ways on which the work table moves are exactly at right angles with each other. With the arm in this position the spindle head and the work table can be moved to lay out work by the co-ordinate method without necessity for preparatory set-up or jigging.

These boring machines are made in two models, the leading dimensions of which are as follows :—

	Model "R 2"		Model "R 3"	
	ft.	in.	ft.	in.
Clearance between columns ...	4	9	5	6
Maximum distance between spindle and baseplate	4	0	5	0
Maximum distance between drilling spindle and table	2	6	3	3
Maximum radius	3	6	4	0
Vertical travel of radial arm ...	1	9	2	3
Size of work table	3 3" × 3 0"		4'0" × 3 9"	
Table travel	3	3	4	0
Travel of spindle	11½ in		4½in	
Spindle Speeds No.	18		18	
Spindle Speed Range in r.p.m.	28–1400		30–1500	

One of the grinding machines of new design is the Keighley "KL," which is fitted with hydraulic motions for table traverse, quick approach of wheelhead, plunge cut and intermittent feeds. The table traverse is infinitely variable between ¼in and 17ft per minute, the hydraulic feed mechanism is applied at every reversal of the table—the feed range being 0·0001in to 0·001in, and the plunge cut feed is readily and infinitely variable. The work headstock is so constructed that it can operate with either live or dead centre, with infinitely variable spindle speeds, the speeds being obtained from a d.c. motor having thyratron control gear. If required, the machine can be supplied with workhead arranged for collet chuck work, the collets being lever operated. A range of equipment available for the machine includes a time sizing control unit and an internal attachment.

GEO. JACKMAN MACHINE TOOL COMPANY, LTD.

Machines of relatively simple design but having a very useful range of application, are the horizontal disc grinders made by the Geo. Jackman Machine Tool Company, Ltd., 29, Derby Road, Enfield, Middlesex. As can be inferred from the photograph of the 53in diameter wheel machine, reproduced

FIG. 15—DISC GRINDER—JACKMAN

in Fig. 15, these machines can be used by semi-skilled labour for grinding large, flat surfaces on such components as covers, housings, &c.

The corrugated segmental grinding wheel is mounted on a large roller bearing spindle driven through vee belts by a motor at the rear of the machine. A work rest bar set across the width of the wheel is adjustable for height and incorporates a dressing device. These machines are made in various sizes with wheels from 8in to 72in in diameter.

This firm also exhibits a useful range of the familiar vertical disc grinders and duplex grinding machines for the finishing of two ends of a component simultaneously.

CENTRAL TOOL AND EQUIPMENT COMPANY, LTD.

The exhibits of the Central Tool and Equipment Company, Ltd., Church Terrace, Richmond, Surrey, include an interesting little milling machine which has been developed for the mass production of small parts. This machine has a table 6in by 18in which has means of traverse in the longitudinal direction only.

For vertical movements the head slides bodily up and down on the column, and for cross movements the quill containing the spindle moves out of the head. These movements are only used for setting up purposes, and during machining both are locked.

The main drive of the machine is by a d.c. motor fed and controlled electronically from a three-phase a.c. supply. The spindle speeds are infinitely variable from 100 to 3000 r.p.m., the speeds being controlled by a simple dial operating a rheostat. This rheostat controls the speed in two overlapping speed ranges, of 100 to 600 r.p.m. and 500 to 3000 r.p.m., which are selected by a gear change lever at the back of the machine. The spindle horsepower over part of the speed range is constant and is proportional to the speed over the remainder.

A hydraulic table feed gives an automatic operating cycle providing a fast approach of the work to the cutter, slow feed and fast return. If required this cycle can be repeated twice on the same stroke when two jigs are employed.

JOHN LANG AND SONS, LTD.

A comprehensive range of lathes of modern design and construction are shown by John Lang and Sons, Ltd., of Johnstone, near Glasgow. In addition to 13in, 16in and 28in swing sliding, surfacing and screwcutting lathes, there is a 20in machine fitted with electronic contouring equipment, and three surfacing and boring lathes, with swings of 17in, 20in and 26in respectively.

The 28in sliding, surfacing and screwcutting machine we illustrate in Fig. 16 has a 15ft bed and takes work up to 6ft 10in long between its centres. It can swing 18¾in over the saddle with the cover removed and 14½in with it on. The all-gear fast headstock is arranged for twelve spindle speeds from 6·5 to 330 r.p.m. Drive is transmitted through forward and reverse plate clutches controlled from the front of the bed and the apron.

The spindle runs in a pre-loaded roller bearing at the front and its flange is fitted with a locking ring which facilitates the interchanging of the driving plate, face plate and chucks.

The machine has a multi-change gearbox which gives a range of twenty-eight normal feeds and threads. At the six lower spindle speeds a special range of twenty-eight coarse threads and feeds are available,

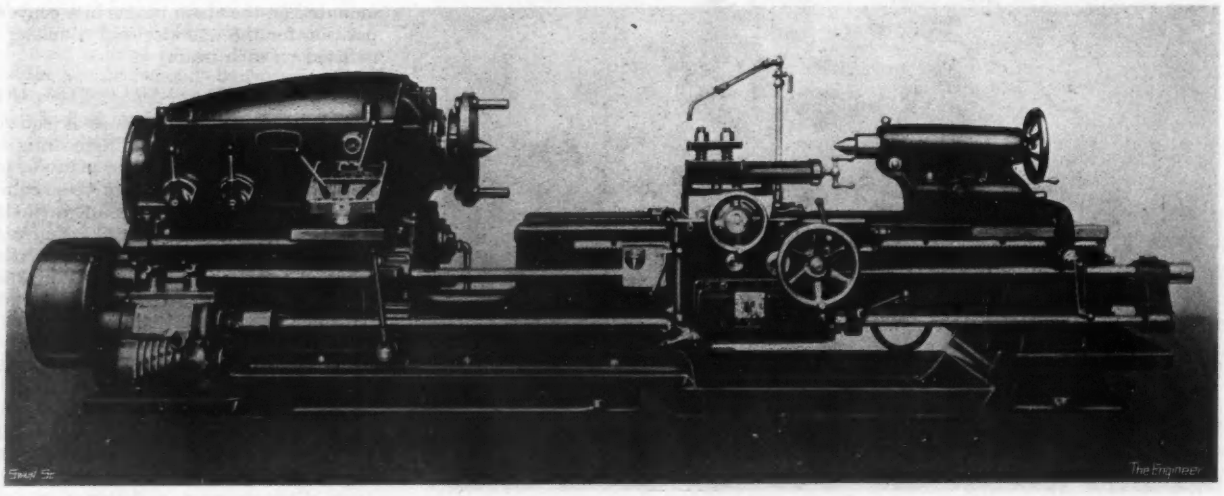


FIG. 16—28IN SLIDING, SURFACING AND SCREWCUTTING LATHE—LANG

and a similar number of fine feeds is available at the six higher spindle speeds.

The 20in swing machine fitted with contouring equipment has a gap bed in which work 34in diameter can be swung, whilst 11¼in can be swung over the saddle. Its all-gear headstock has twelve spindle speeds from 10 to 500 r.p.m., and the gearbox gives a range of twenty-eight feeds.

When this machine is used for automatic copying, the motion of the tool slide is controlled by means of two reversible feed motors which drive the longitudinal feed screw and cross drive shaft respectively through gearboxes located at the tailstock end of the machine.

An electro-magnetic follower head mounted on the cross slide has its sensitive stylus point in contact with the profile of a fixed template mounted behind the saddle.

Any displacement of the stylus relative to the body of the follower is resolved electrically into two components which are parallel to the longitudinal and cross feed directions respectively. The resulting electrical signals are amplified electronically and arranged to control proportionately the speeds of the two feed motors in such a way that the stylus moves smoothly along the contour of the template.

With this equipment the only supervision necessary is occasional adjustment of a control to determine the general directional bias of the cutting tool, having regard to the slope of the template at the point of contact with the stylus and the direction in which the operator wishes the tool to traverse the work.

GEORGE RICHARDS AND CO., LTD.

George Richards and Co., Ltd., of Broadheath, near Manchester, is showing one of its larger sizes of universal horizontal boring, facing, milling, drilling and tapping machines. This machine (see Fig. 17) has a traversing spindle 5in in diameter and is designed to face work up to 54in diameter. Its traversing spindle and facing head can be revolved either independently or simultaneously and a wide range of speeds is provided to both units. The makers point out that in order to relieve the main bearings of the high pressures involved in belt drives the main spindle of this machine is driven by roller chains.

The main table is 7ft 3in by 4ft and a 5ft square revolving table mounted on it is fitted with the firm's patented squaring lock, which is designed to ensure absolute squareness between all four sides in the work. The facing slide has eight feeds from 0·01in to 0·125in per revolution. A range of eight feeds from 0·005in to 0·063in per revolution is provided for the longitudinal and transverse table movements and for the spindle assembly vertical movement. The traversing spindle has thirty-six speeds from 1·65 to 300 r.p.m., twelve from 45 to 300 r.p.m. being independent. Twenty-four speeds in the facing head cover the full range from 1·65 to 300 r.p.m.

Rapid power traverse, driven by independent motor, is provided to all sliding units, and a separate motor, giving longitudinal movement to the boring stay and vertical movement to the stay bearing, is also fitted. The machine is of the totally enclosed type, and the bed slides and bed screw are covered to prevent damage by swarf and other foreign matter. Rules and verniers are fitted to the vertical and transverse movements for means of rapid adjustment to a high degree of accuracy, the reading of the verniers being facilitated by the provision of magnifying glasses. All electrical motions are push-button controlled from a seven-point pendant, which can be swung to any position for the convenience of the operator.

Among the vertical boring and turning mills exhibited by this company is a high-speed model designed to take work up to 6ft diameter. It has one standard swivel head and a six-side, non-swivelling turret head on the cross slide. The table is carried on large diameter ball and roller bearings and has a speed range from 4·46 to 200 r.p.m.

The main driving motor has a speed range of 5 to 1, which is infinitely variable by electronic control. The right-hand turret head is arranged to operate the speed control to the table automatically in order to give constant cutting speed for surfacing operations. This automatic control can be engaged or disengaged by means of a switch. There are sixteen feeds available to both heads, ranging from 0·0025in to 0·2255in per revolution.

A heavy-duty railway wheel boring and turning mill for work up to 56in in diameter has been specially designed to deal with solid wheels. This machine has two hexagonal non-swivelling turret heads, the right-hand one of which is fitted with an electronically controlled copying attachment for machining the whole contour of the wheel. Its left-hand head has a separate motor driving the feed box, which gives a feed range of 0·506in to 3·95in per minute, for machining the bore and annular recesses.

The crankpin turning machine shown in Fig. 18 will turn pins up to 10in diameter. In it the crankshaft is held stationary, whilst the tool for turning the crankpins and inside surfaces of the crankwebs is carried round it on a revolving slide. This slide revolves in a circular housing mounted on the bed, and is carried in an adjustable double-cone bearing driven by a pinion through the main gearbox. The power is supplied by a variable-speed motor giving an infinitely variable speed range from 4·66 to 27·4 r.p.m.

The crank is held whilst the cut is taken on pillar blocks bolted to two sliding tables on the machine bed, one table being on each side of the circular housing.

The turning tool has both automatic and

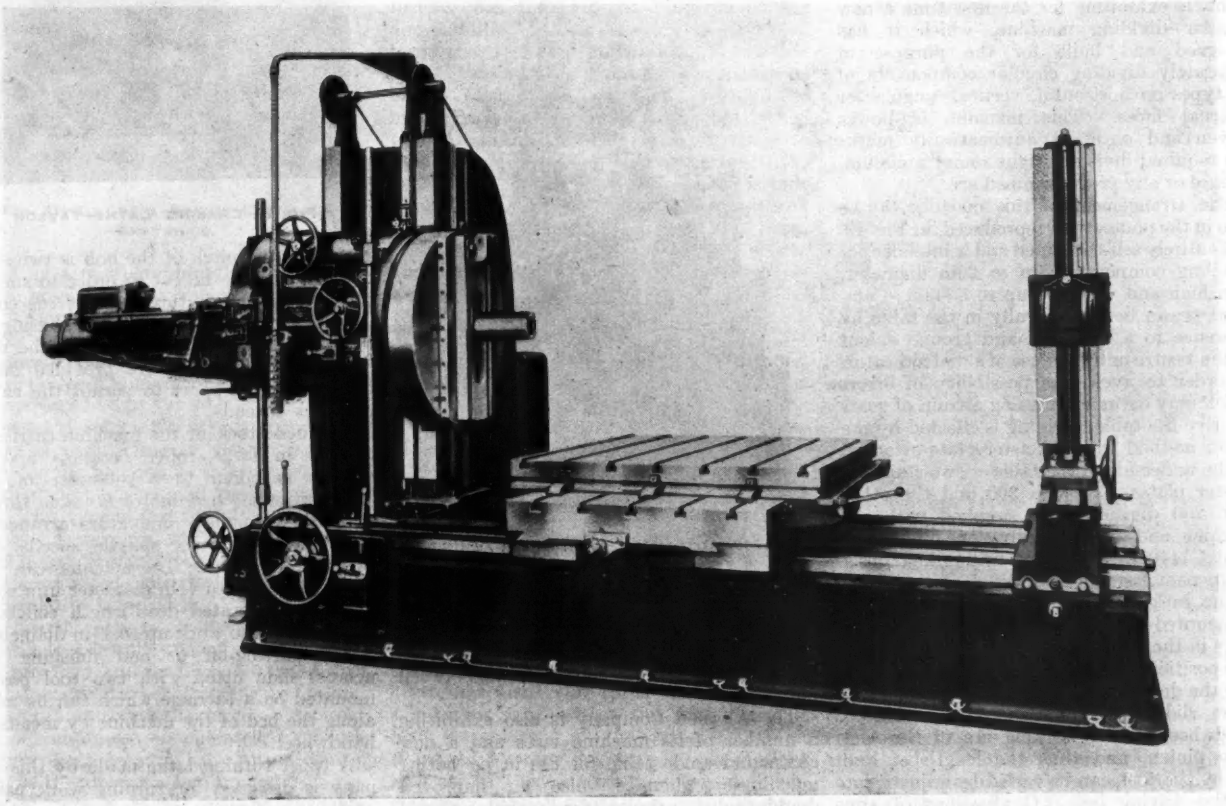


FIG. 17—BORING, FACING, MILLING AND DRILLING MACHINE—RICHARDS

hand feeds through a worm and screw, and is in compression while cutting, all the slides and bearings supporting the tool slide being directly under the centre of the tool. This arrangement is intended to eliminate spring and jar during machining and allows cuts

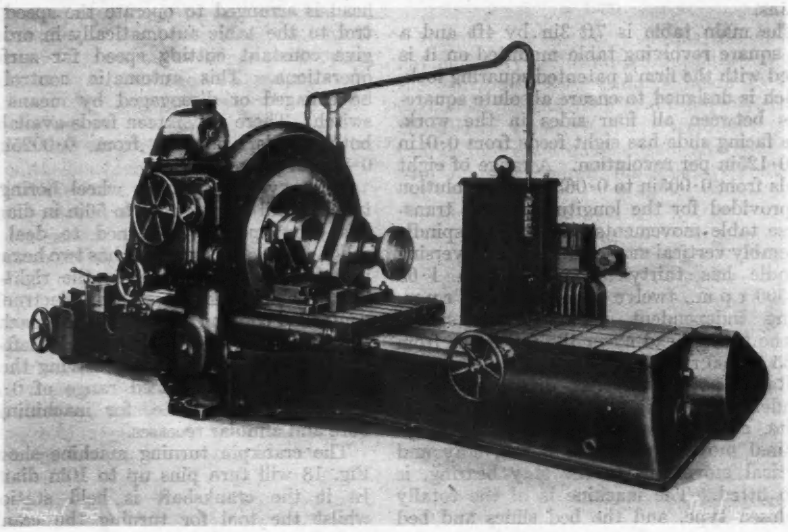


Fig. 18—Crankpin Turning Machine—Richards

of 0·01in per revolution to be taken with a wide tool. The tool can be made of sufficient width to take the whole surface of the pin at one cut, or alternatively, a narrower tool can be used, in which case the surface of the pin is machined by traversing the work-supporting tables longitudinally along the bed.

Abwood Tool and Engineering Company, Ltd.

The Abwood Tool and Engineering Company, Ltd., of Princes Road, Dartford, Kent, is exhibiting for the first time a new circular dividing machine, which it has designed and built for the purpose of accurately dividing circular components of all types on horizontal, vertical, angular or internal faces. This machine is power driven and once set automatically marks the required divisions right round a circumference or any predetermined arc.

The arrangement of this machine can be seen in the photograph reproduced in Fig. 19. It is entirely self-contained and is intended for handling components up to 20in diameter, 18in high and weighing up to 500 lb. Components can be set centrally in the table by reference to a hardened and ground spigot in the centre or by the use of a dial indicator. In order to avoid the possibility of errors which may occur when using a train of gears to drive the table, dividing is effected by the direct method with a master plate attached to the underside of the table. Two standard master plates, one with 360 and the other with 200 divisions, are supplied with the machine, and with them divisions numbering up to 1440 or 800 may be marked on a component.

The rack and pinion-operated tool slide is mounted on a horizontal slide carried on ways in the vertical column of the machine. The position of the tool in respect to the work and the depth of cut is set by adjustment of these slides with reference to graduated handwheels. The working arc of the tool slide pinion, and thus the length of line cut by the tool, can be varied by adjustment of the driving link. Graduations of any length up to $\frac{3}{4}$in can be cut. The tool slide mechanism incorporates means whereby long and intermediate lines can be cut automatically in correct preset sequence, six independent combinations of line lengths being available.

A counter coupled to the tool slide drive can be preset to the desired number of divisions and when these have been cut it operates a trip to stop the machine.

The table is indexed between each cut by a lever driven by an eccentric on the side of the machine. This lever rocks a graduated intermediate slide, which controls the number of divisions cut on the component by the setting of a slide block at the appropriate number. This block is

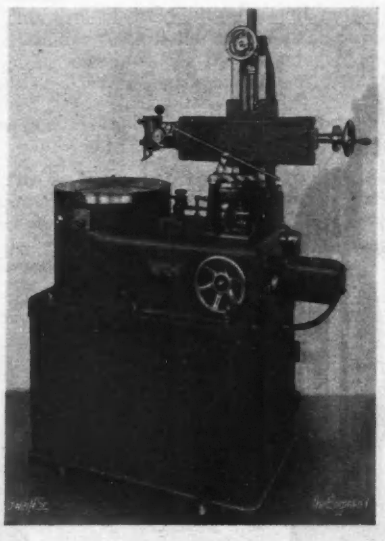


Fig. 19—Automatic Dividing Machine—Abwood

coupled by a push rod to a pawl mechanism, which registers in the teeth round the circumference of the master plate and moves the table by the required increments between cuts.

The Abwood Company is also exhibiting a number of its machine vices and a new compound angle table for use in jig boring machines. There is also an improved double-ended grinder for carbide tipped tools which incorporates some very useful features. On each of the tables fitted in front of the grinding wheels of this machine is an engraved protractor tool rest. This rest when used in combination with the trunnion-mounted table considerably facilitates the grinding of tools to the correct angles.

Charles Taylor (Birmingham), Ltd.

The plant on the stand of Charles Taylor (Birmingham), Ltd., Bartholomew Street, Birmingham, 5, includes this firm's latest product, the "Dellmac" chasing lathe. This machine is intended for the high-speed production by semi-skilled labour of accurate threads up to 2in long.

In this lathe—see Fig. 20—the chasing slide and arm are mounted on a carriage which is moveable along a rigid member supported between heavy brackets at the rear of the bed. The carriage is traversed along the supporting member by a half-nut, which engages with the hob. The hob is mounted on the axis of the carriage and its supporting member and is engaged by the depression of a ball-ended lever on the headstock. The chasing mechanism is situated directly behind the lathe spindle and the hob is driven through gearing at half the speed of the spindle. The arrangement is

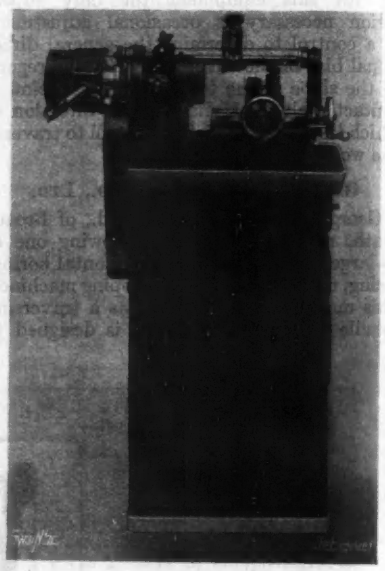


Fig. 20—Chasing Lathe—Taylor

such that the pitch of the hob is twice that of the thread to be cut in order to simplify the cutting of fine threads. At the end of its set machining traverse the chasing tool is automatically withdrawn from the work. Means of adjustment are provided on the chasing slide support to permit the cutting of taper threads.

The headstock of the machine carries the spindle in large roller bearings and the spindle is bored to a diameter of $1\frac{3}{8}$in. Drive from a $\frac{3}{4}$ h.p. motor is taken through stepped vee pulleys and gears arranged to give a range of six spindle speeds, from 320 to 1300 r.p.m. The machine can carry components up to $4\frac{1}{8}$in diameter in a chuck, and hand operated dead-length collets can be used to take work up to $1\frac{1}{4}$in diameter.

For parting-off or end finishing work a cross slide fitted with two tool posts is mounted on a carriage which can be moved along the bed of the machine by means of a handwheel.

A taper turning lathe made by this company is designed for turning work parallel or taper, up to 10 deg. included angle and 7in in length. In this machine work can

also be screwed, drilled, tapped, formed and faced. When fitted with a standard automatic chuck and collets, work up to 1 1/16in diameter can be accommodated but special equipment is supplied if required to increase the capacity to 2 1/4in diameter.

A lever-operated back centre is fitted with a four-tool capstan, which can be replaced by a wheel back centre and centre point if required. The traversing slide is power driven in both directions by two screws in the bottom slide. One of these screws has a coarse pitch for roughing and the other a fine pitch for finish machining on the return feed. A cam and handle operated tool holder is designed to permit the rapid changing of tools, stops being provided to set the cutting tool edges in the work centre line.

Other machines being shown upon this stand include a 6in capstan lathe, a 12 1/2in centre spinning lathe, a milling machine for brassfounders, and a saw grinding machine.

BRAYSHAW FURNACES AND TOOLS, LTD.

The comprehensive range of small and medium industrial furnace equipment shown by Brayshaw Furnaces and Tools, Ltd., of Belle Vue Works, Manchester, 12, is supplemented by a photographic display of many of the larger installations made by the firm. A number of gas and electrically heated furnaces are to be seen in operation, and we are informed that, if required, alternative oil-fired types of equipment can be supplied in many cases.

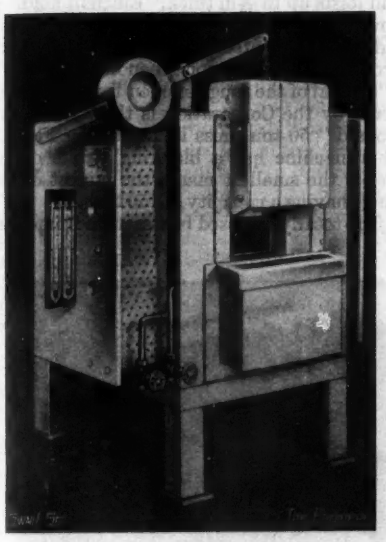


FIG. 21—ELECTRIC BENCH FURNACE —BRAYSHAW

A recent development of this company is a range of oven furnaces, heated by electricity, for the hardening of carbon steels or annealing, normalising and preheating purposes. This type of furnace has a maximum working temperature of 1000 deg. Cent. In the larger furnaces the inner refractory lining is provided with locked joints, and extra insulation is included.

The hearth plate is of silicon carbide, or alternatively, an alloy steel hearth plate can be provided, and the furnace is fitted with a hand-operated door of the rising and falling type suitably counterbalanced. Alternatively, a compressed air-operated door with foot control can be supplied. An automatic switch in the door mechanism cuts off the supply of current to the heating elements when the door is opened.

Two gas-fired, twin-chambered, high-speed steel furnaces on view as working exhibits represent the latest range of standard impact-heating furnaces for treatments up to 1400 deg. Cent. Recent developments include an improved burner arrangement, protection of the work from flame impingement, provision of work shelves and a tool rack for tongs, &c., and improved damper control.

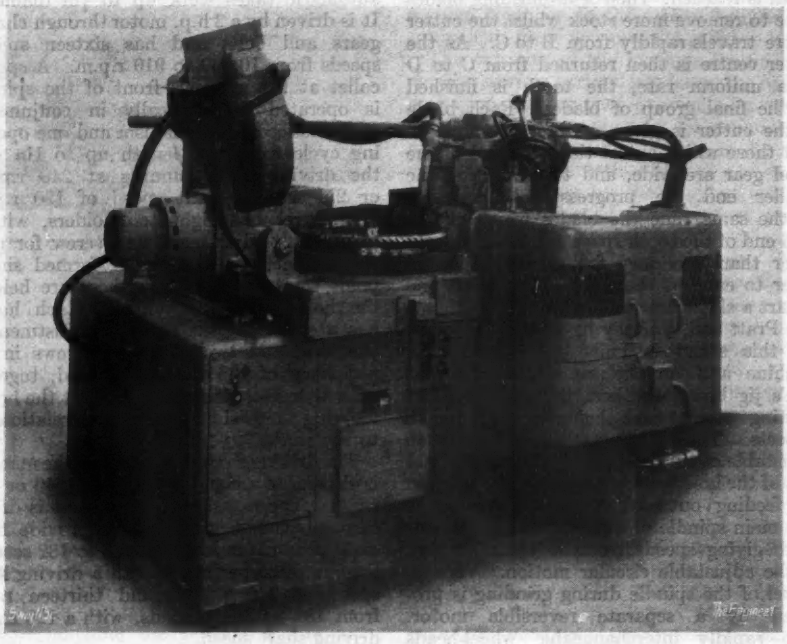


FIG. 22—"REVACYCLE" BEVEL GEAR CUTTING MACHINE—BUCK AND HICKMAN

An electrically operated bench type furnace (see Fig. 21) for hardening high-speed steel is specially suitable for tool room use. This furnace has four heating elements of the non-metallic "Globar" type, with air-cooled terminals, mounted horizontally above and below the working hearth. Carbonaceous blocks with trays which fit within the muffle can be supplied for use when processing small delicate work in order to reduce scale formation to a minimum. The hearth and baffle plates of silicon carbide afford rapid heat transmission without risk of warping. The furnace is capable of working temperatures up to 1400 deg. Cent., and is equipped with a gas burner to provide a protective atmosphere.

BUCK AND HICKMAN, LTD.

A large number of American machines, of new and improved design, to be seen upon the stands of Buck and Hickman, Ltd., 2–8, Whitechapel Road, London, E.1, are of particular interest.

Among these machines is the new Gleason "Revacycle" bevel gear cutter, which has been developed for cutting straight bevel gears with conjugate teeth surfaces at a high production rate. This machine uses a large diameter disc cutter with blades extending radially outwards. Each blade or cutting tooth has two concave cutting edges of correct form to produce convex profiles on the gear teeth. The cutter rotates in a horizontal plane and turns continuously at a uniform rate, whilst the gear blank is held stationary. As the cutter rotates it is moved by cam mechanism in a straight line across the face of the gear and substantially parallel to its root line. There is no depthwise feed of the cutter into the work, the effective feed being obtained by making each cutter blade progressively longer than the preceding one. The cutter incorporates three kinds of blades—roughing, semi-finishing and finishing—and in one revolution it completes each tooth space in the gear blank.

In this machine—to be seen in Fig. 22—the blank is placed on the work arbor and movement of a hydraulic control lever clamps it in position and moves the workhead into its operative position. After each tooth is cut the blank is automatically indexed at a gap in the cutter blades. Cutting feeds range from 5·5 to 1·96 seconds per tooth.

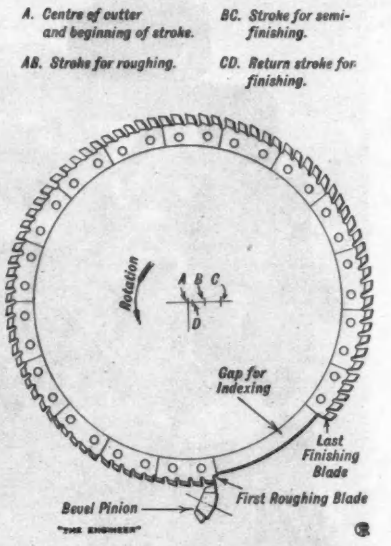


FIG. 23—ACTION OF GEAR CUTTER —BUCK AND HICKMAN

The working cycle completed by each revolution of the cutter can be followed by reference to the diagram, Fig. 23. The first blade just nicks the crown of the blank and the cutter centre is at point A, the toe-end of the stroke. As the cutter rotates counter clockwise the blades gradually

increase in length until the root line of the tooth is reached. During the first part of this roughing operation the cutter centre is moved from A to B, by the cam mechanism, where it remains until the full tooth depth is reached. Then semi-finishing blades serve to remove more stock whilst the cutter centre travels rapidly from B to C. As the cutter centre is then returned from C to D at a uniform rate, the tooth is finished by the final group of blades. Each blade of the cutter is given a different shape so that those which cut at the large end of the bevel gear are wide, and those cutting the smaller end are progressively narrower. At the same time the blades which cut at each end of the tooth space are made slightly wider than necessary for correct taper, in order to ease off the ends of the tooth and impart a slight crowning effect.

A Pratt and Whitney jig-grinding machine on this stand is built as a companion machine and on the same lines as that firm's jig borer, the bed, table and various locating mechanisms being similar in all respects. The grinding wheel head has an adjustable circular motion about the vertical axis of the hole being ground, and is designed for feeding outward to the finished size. The main spindle of the head has a variable drive giving speeds from 35 to 200 r.p.m. to the adjustable circular motion. Vertical travel of the spindle during grinding is provided by a separate reversible motor. Two rapidly interchangeable wheel-heads are supplied with the machine and each has a built-in motor, the rotor of which is assembled directly on the grinding-wheel spindle. Each wheelhead has eight speeds, those for the smaller one, designed for holes up to 1in in diameter, ranging from 13,200 to 54,000 r.p.m. The larger head, for grinding holes from 1in to 5in diameter, has speeds from 6600 to 27,000 r.p.m.

The main head of the machine has a travel of 15in and the grinding spindle has a vertical travel of 6in. Angular adjustment is provided for grinding holes up to 5 deg. included angle.

Another machine exhibited for the first time is a new Brown and Sharpe automatic pinion turning machine. This single-spindle automatic takes work up to $\frac{1}{4}$in diameter. It is driven by a 2 h.p. motor through change gears and belts and has sixteen spindle speeds from 10,000 to 910 r.p.m. A spring-collet at the extreme front of the spindle, is operated automatically in conjunction with the feeding mechanism and one operating cycle feeds any length up to 1in with the driving shaft running at 240 r.p.m., or 2in with a shaft speed of 120 r.p.m. The turret has eight tool-holders, with a micrometer adjustment stop screw for positioning each tool. Circular formed single-point tools are used and these are held in the holders by the screws. Each holder has a screw for the forward adjustment of the tool, and two adjusting screws in the periphery of the turret are used, together with a tool-centring gauge, to set the holder to bring the tool edge in correct relationship to the work.

The driving shaft at the rear of the machine is driven at a constant speed of 240 or 120 r.p.m. The camshaft at the front is driven through change gears, which provide fifty-eight production rates, from 3 to 182 seconds for one piece per cycle, with a driving shaft speed of 240 r.p.m., and thirteen rates, from 184 to 364 seconds, with a 120 r.p.m. driving shaft speed.

Also of interest is the Bryant internal grinding machine for bores of less than 1in diameter. In order to attain the very high spindle speeds essential for successful internal grinding of small holes, this firm has developed a special wheelhead. In this wheelhead a specially designed dynamically balanced high frequency motor directly drives the spindle at 100,000 r.p.m. The spindle is mounted on pre-loaded ball bearings, and is mist lubricated by oil, which is dropped into a stream of compressed air fed over the spindle and bearings, at a pressure of 12 to 15 lb per square inch. A cooling water jacket is fitted round the spindle housing to keep the wheelhead temperature constant.

SCOTTISH MACHINE TOOL CORPORATION

Two machines are being exhibited on the stand of the Scottish Machine Tool Corporation, Ltd., of 58, Victoria Street, London, S.W.1, in addition to a selection of photographs of the many types of heavy machine tools it builds. Although in the range of smaller plant made by the Corporation, the two machines have been selected as typical of its standards of design and workmanship.

One of these machines is shown in Fig. 24. It is a "Bennie" splitting shear, incorporating a punch, bar, angle and tee bevel cropper, and a notcher. It is driven by a 6 h.p. motor through vee ropes and is of steel plate construction. On it holes up to 1in diameter can be punched through $\frac{1}{2}$in thick mild steel plate, and plates of this thickness and unlimited length can be sheared. The cropper has the following capacity:—At 90 deg. angles and tees up to $4\frac{1}{2}$in by $4\frac{1}{2}$in by $\frac{5}{8}$in, and at 45 deg. angles up to $3\frac{1}{2}$in by $3\frac{1}{2}$in by $\frac{5}{8}$in, and tees up to 3in by 3in by $\frac{5}{8}$in. Rounds and squares up to $1\frac{1}{8}$in can be cleanly cut and notches made in plates, channels and joists up to $\frac{5}{16}$in thick. Efficient holding-down gear and stops for bevelling are provided. The notcher has a guard to give protection to these tools when not in use.

Typical of the range of open-fronted presses made by the Corporation is the "Craig and Donald" 50-ton press illustrated in Fig. 25. This machine has a blanking stroke of 1in and is the smallest made, the largest of the range having a capacity of 150 tons.

The totally enclosed box-section frame contains all the mechanism, including the motor drive, fly-wheel, clutch and gearing. All parts are made easily accessible for maintenance and adjustment through large inspection doors. The press is controlled by a push-

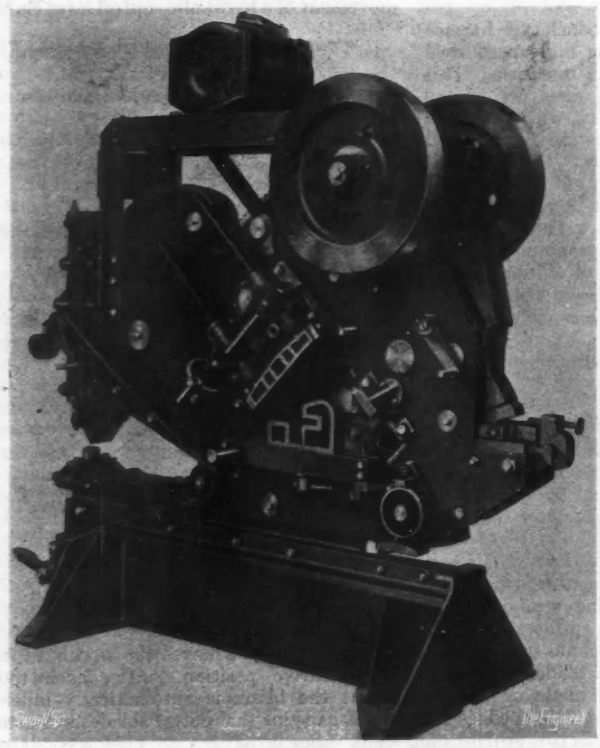


FIG. 24—SPLITTING SHEAR—SCOTTISH M.T.C.

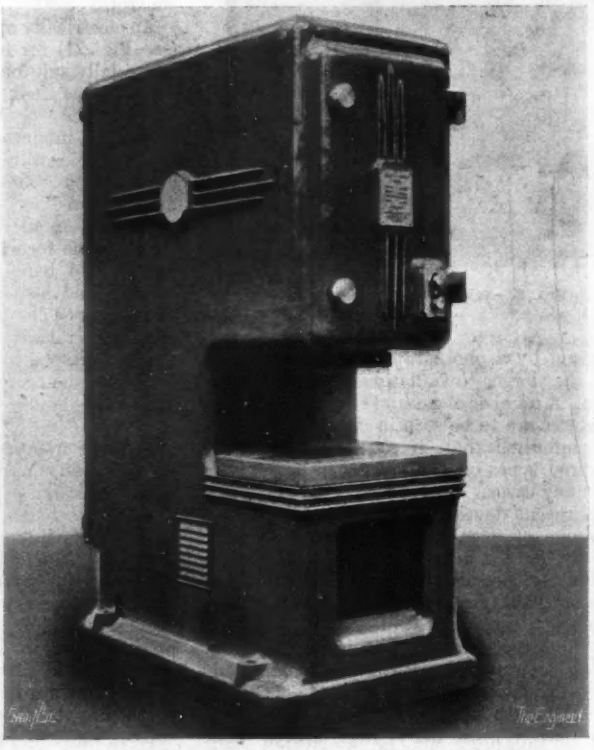


FIG. 25—50-TON PRESS—SCOTTISH M.T.C.

button-operated electro-pneumatic friction clutch of the multi-plate shockless type.

This machine has a cast frame, but the larger sizes have welded steel frames of four-piece tie rod construction.

TAYLOR, TAYLOR AND HOBSON, LTD.

In addition to the machines on its own stand in the National Hall, Taylor, Taylor and Hobson, Ltd., of Leicester, has a selection of its precision measuring and inspecting equipment on the stand of the British Engineers Small Tools and Equipment Company, Ltd., and an interesting new "Genoptic" profile grinding machine on the stand of the Coventry Gauge and Tool Company, Ltd.

In Fig. 26 we illustrate this company's hand-operated pantograph milling and die-sinking machine, which has been developed for machining complex surfaces and producing all forms of dies, moulds, contours and irregular forms. It comprises a high-speed vertical milling spindle coupled to a tracer by a pantograph arrangement, through which the motion of the cutter follows the path of the tracer, both horizontally and vertically. The worktable is 15in long by 8in wide and has a horizontal movement of 12in, a transverse movement of 8in, and a vertical movement of 9in.

Reduction by means of the pantograph is variable from 1½ to 1 down to 7 to 1, and the spindle and tracer can be interchanged to enlarge instead of reduce. The pantograph mechanism incorporates a ratchet-operated feed to permit systematic traversing over the work, and the feed can be instantly disengaged to allow full flexibility when it is required to follow the detail of an intricate design. A graduated micrometer dial is provided to control the spindle setting for the depth of cut. The vertical motion of the spindle can also be controlled by means of a counterweighted beam extending across the spindle and tracer to ensure copying in the vertical direction in the same ratio as in the horizontal direction.

This company has also developed a chasing lathe for second operation work in dealing with parts cut from the bar, or tube, or within individual castings. The spindle of this machine carries at its rear end a master lead-screw, which automatically engages with a half-nut, the whole of the spindle rocking on a shaft in and out of engagement by means of an eccentric with suitable tripping devices.

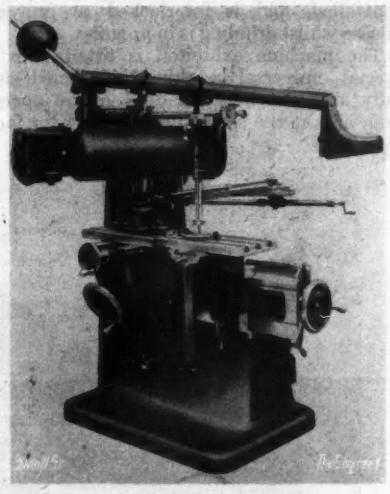


FIG. 26—PANTOGRAPH MILLING AND DIE-SINKING MACHINE—TAYLOR, TAYLOR AND HOBSON

In this machine the feeding screws have drums with a series of stop plates at the handle end, and each stop is independently adjustable and engages with separate triggers. The arrangement of the stops on the handle itself avoids possibility of straining of the screw or the frame of the machine, which may lead to possible variations is sizing.

The "Genoptic" profile grinding machine, see Fig. 27, is being shown for the first time. It is designed to provide a rapid and accurate way of form grinding and combines the advantages of mechanical generation and copying by optical projection. The design ensures that the behaviour of three elements, one for supporting the work, the others for control and reference respectively is identical, and operation may be effected by hand or in some instances by servo motor. In the case of generation the reference is constituted by a system of optical scales, which are projected on to a viewing screen to facilitate the use of right-angle or polar co-ordinate measurements to identify and locate a given point, or, in the case of copying, an equivalent form is similarly projected.

The capacity of the machine for flat and circular work is particularly large, the optical limitations having been overcome by adopting a system of scanning, for scales and copy, which enables the illumination to be concentrated over a practical field.

When operating by the copying method, a full-size outline of the required profile is produced photographically and then projected at forty magnifications. This, together with the ability of the machine to generate geometric elements from basic data by gyratory or translatory methods of control, makes possible the production of intricate forms with great accuracy.

In addition to its use for grinding profile gauges, form tools, cams, &c., the machine is equipped with the means for generating involutes and may be used for grinding the teeth of pinions and gear-shaping cutters within its capacity.

The reciprocating wheel-head has an adjustable stroke and embodies means of compensating for wheel wear. The wheel may at all times be observed through a ×25 microscope and may be trued against an optical reference of the same magnification.

We are informed that the manufacturers accept responsibility for providing the necessary photographic copy to users' drawings where facilities for its making are not available to the user.

FREDK. POLLARD AND CO., LTD.

The many types and sizes of drilling machines exhibited by Fredk. Pollard and Co., Ltd., Corona Works, Leicester, include the interesting three-way vertical cam-feed unit machine, illustrated in Fig. 28.

This machine, which is shown in operation, has been built for the purpose of drilling forty-five holes in typewriter top plates. In it the three drilling units, mounted on

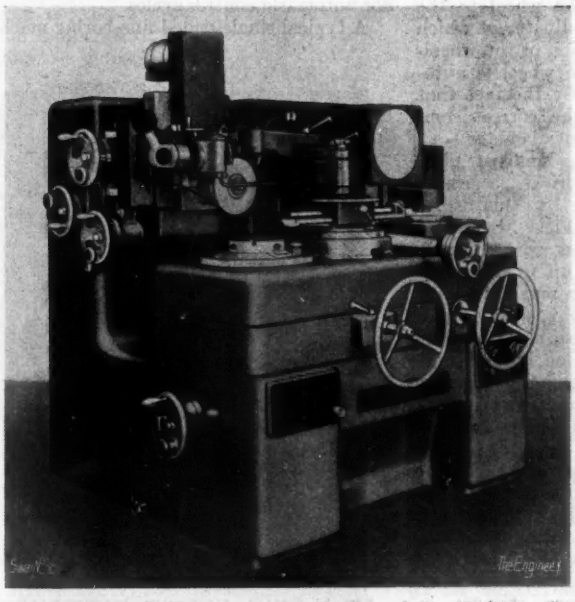


FIG. 27—PROFILE GRINDING MACHINE—TAYLOR, TAYLOR AND HOBSON

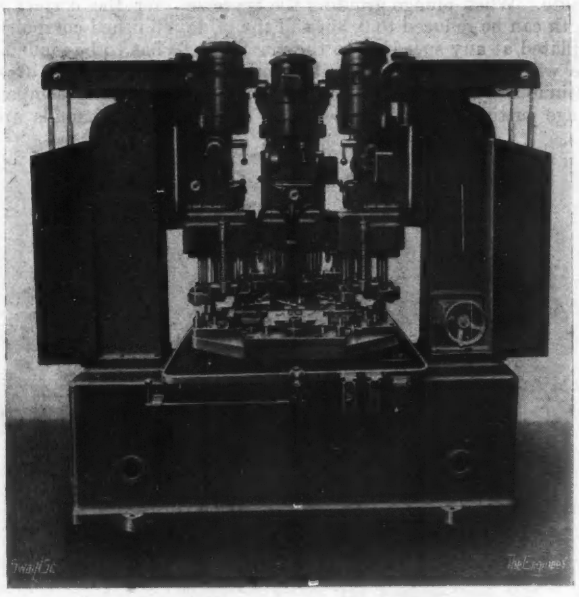


FIG. 28—MULTI-UNIT DRILLING MACHINE—POLLARD

columns, are located over and around a four-station, motor-driven indexing work-table carrying the fixtures. The whole assembly is mounted on a fabricated steel base. Two of the multi-spindle drilling heads have fifteen spindles, and the third seventeen spindles. The respective spindles take drills varying from 0·109in to 0·242in diameter, and two 0·25in reamers. Each spindle is geared to run at a speed appropriate to the size of drill it carries.

The cam feed is arranged to provide quick approach and return of the heads with the correct rate of feed during the actual drilling period. To prevent undue strain on the feed mechanism, each complete unit assembly is counterbalanced by weights. In operation, components are loaded on to the fixture at one station whilst drilling is in progress at the other three. Interlocking devices prevent the feed mechanism operating unless the table is correctly indexed and locked, and the machine automatically stops at the end of each drilling cycle.

Other machines laid out for special purpose work, which can be seen upon this stand, include one for drilling and reaming shock-absorber pistons, another for drilling and counterboring small holes round piston heads, and a third for rough and finish boring the main holes in motor-car gearboxes.

JOHN LUND, LTD.

Visitors to the exhibition who are interested in fine boring with diamond and carbide-tipped tools and in precision grinding will find the stand of John Lund, Ltd., of Cross Hills, near Keighley, well worth a visit. The eleven machines being demonstrated are representative of the latest designs of this firm's products.

Among the larger equipment is a plain cylindrical grinding machine fitted with a 26in diameter wheel, 7in wide. This machine, illustrated in Fig. 30, takes work up to 14in diameter and 40in long, and is hydraulically operated. It has an infinitely variable rate of table traverse from 9in to 190in per minute. When plunge grinding the traverse length can be reduced to 0·3in and the table oscillated at any speed up to the maximum. The wheel can be fed into the work at a continuous and infinitely variable rate for plunge cutting with the table either at rest or oscillating. Alternatively the machine can be set for intermittent feed during traverse grinding, the feed range being from 0·0001in to 0·001in in increments of 0·0001in.

In addition to hydraulic table traverse the machine has a hydraulically operated quick wheelhead approach and withdraw movement. This movement not only facilitates the loading and unloading of components, but also enables the work to be gauged whilst in position opposite the wheel itself. The hydraulically operated tailstock normally fitted to this machine is pedal controlled, and is interlocked to prevent release whilst grinding is in progress.

The machine exhibited is fitted with a special universal workhead designed for fully universal live and dead centre operation, and at the same time allowing for face grinding at 90 deg. angle to the table. It also has a hydraulically operated form-truing device in which the axis of a spring loaded top slide, carrying several diamonds, is set at an angle of approximately 45 deg. to the base slide. This arrangement makes it possible to true right-angled corners on the wheel with only one movement of the main base slide. This truing equipment is mounted on the table behind the tailstock, and the diamonds can be set permanently for the correct sizing of the wheel to the finished component. Any adjustment which has to be made to the position of the wheelhead during dressing of the wheel is automatically compensated for by the fact that the diamonds are set for the correct component diameter.

The smallest plain cylindrical grinder made by this firm—see Fig. 31—is intended for components up to 1¼in diameter and 12in long. It is specially built for use as a finishing machine for the high precision production of small parts such as diesel fuel pump pistons, injector valve needles, &c. The machine has a hydraulically operated table and, in order to avoid variations as a result of temperature changes in the actuating fluid, a thermostatically controlled immersion heater is arranged to maintain the oil temperature in the system within close limits. A special self-compensating type tailstock has a triangular spindle which is designed to remove the effects of backlash, and automatically ensure the return of the spindle to precisely the same position with each component. A spring-loaded ratchet lever operating through the wheelhead hand feed of the machine makes it impossible to strain the feed shaft and screw above a predetermined amount.

In order to take full advantage of the properties of diamond and tipped tools when used for high precision boring of components, such as bearings, where surface finish is of considerable importance, it is best to employ robust machines which incorporate optimum speed and feed variations. It is for this class of work that John Lund, Ltd., developed its "Precimax" precision boring, turning and facing machines. These machines are supplied in a number of forms specially adapted and arranged for special-purpose work on individual components, as well as for general precision machine shop use. Two such special machines to be seen upon this firm's stand are a four-way boring machine and a double-bedded boring machine, each being arranged for automatic control cycles.

A typical single-ended fine boring machine of the medium range is that which we illustrate in Fig. 29, which is fitted with a special fixture as used in the maker's own works for the production of spindle housings for fine boring spindles. In this instance three tools are employed to finish the three main bearing diameters and one locating face.

In these machines the boring heads,

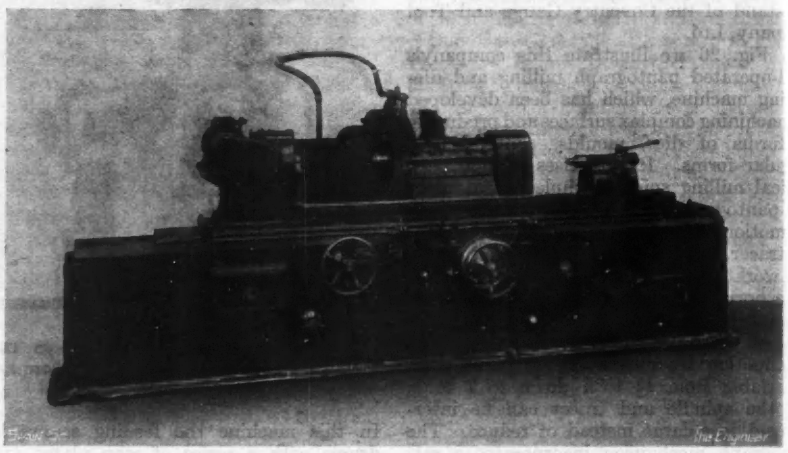


FIG. 30—PLAIN CYLINDRICAL GRINDING MACHINE—LUND

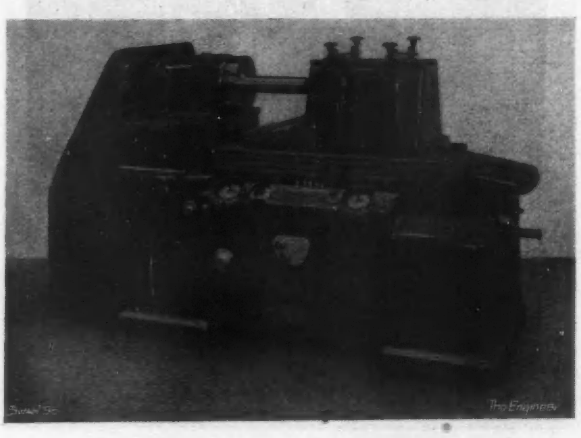


FIG. 29—FINE BORING MACHINE—LUND

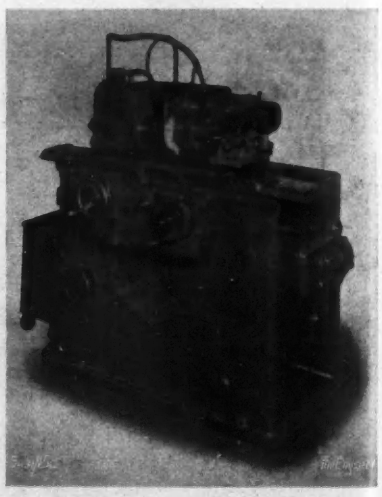


FIG. 31—SMALL GRINDING MACHINE—LUND

are independent units mounted on a bridge over one end of the table. The spindle or spindles are driven by endless vee ropes from balanced motors enclosed within the base. The work-holding fixture is carried on a table resting on full-length vee and flat guideways on the body of the machine. This table is hydraulically operated and has three traverse speeds for quick approach to the boring head, boring feed and facing feed. It can also be arranged for automatic operating cycles with various traverse combinations of fast, slow, start and reverse. Hand control of the table and spindle movement is provided by joystick controllers at the front of the machine.

Independent table lubrication is provided with the object of attaining slow fine boring rates with freedom from shudder and with perfect evenness of movement. Thermostatically controlled immersion heaters on the hydraulic system maintain the oil temperature, and thus the viscosity, within close limits.

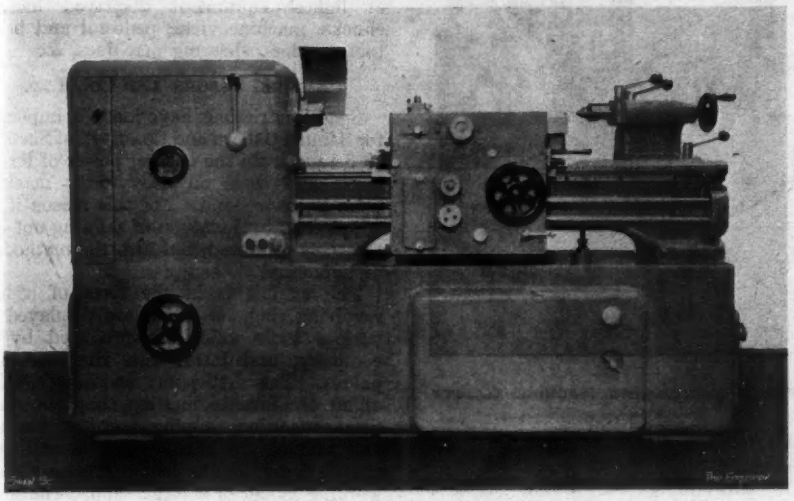


FIG. 32—THREADING MACHINE—SENTINEL

SENTINEL (SHREWSBURY), LTD.

A number of machine tools are now being made by Sentinel (Shrewsbury), Ltd., of Shrewsbury, and from the plant exhibited on this firm's stand we have selected a milling machine, a high-speed threading machine and an interesting little variable speed unit for purposes of illustration.

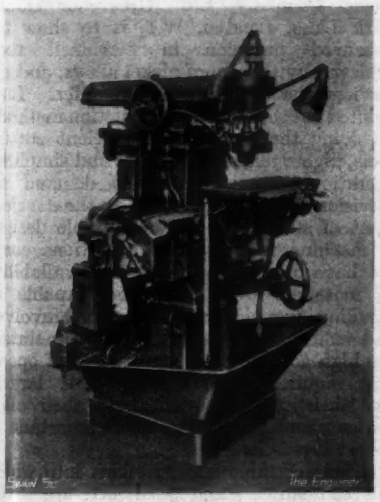


FIG. 33—UNIVERSAL MILLING MACHINE—SENTINEL

The universal milling machine to be seen in Fig. 33 has been specially designed and built to cover a very wide range of machining operations in the tool room. In addition to the usual accessories the company supplies a number of attachments which can easily be fitted to increase the scope of the machine.

The table, which has a working surface of 25in by 8in, can be swivelled up to an angle of 90 deg. to the right or left and tilted through an angle of 30 deg. in a forwards or rearwards direction. Under both hand and power feed the table can be traversed horizontally or vertically over a distance of 12in. The maximum setting distance between the surface of the table and the centre of the horizontal spindle is 12in.

The headstock of the machine moves in dovetail slides on the column, on which it can be traversed by means of a handwheel over a distance of 6½in. An overarm on the headstock has an adjustment of 10in and is designed to support swivelling milling, drilling or slotting attachments over the table. The drive for these attachments is enclosed within the overarm.

For certain classes of work the table of the machine can be removed and replaced by a swivelling dividing head, designed for direct or indirect dividing.

A 3 h.p. motor drives the machine through enclosed chains and a gearbox in which the gears are mounted on splined shafts running in ball bearings. Through the gear-box eight horizontal spindle speeds ranging from 65 to 840 r.p.m., are obtainable.

The "Cri-Dan" threading machine, illustrated in Fig. 32, is of the semi-automatic type and has been designed for use with single pointed tungsten carbide tools. In operation it carries out four distinct and separate movements automatically at high speed. When the tool has made its first cut it is withdrawn, returned rapidly to its starting position and fed in ready for the next cut. At the end of a predetermined number of cuts and when the thread is finished, the machine stops automatically.

A length of 3ft can be accommodated between the centres and the machine is designed to thread external diameters up to 4in and internal diameters up to about 6in. At each setting a maximum thread length of 2½in can be cut.

The machine is motor driven through one of the maker's variable speed units, which can be adjusted through a handwheel over a speed range from 200 to 3600 r.p.m. Drive from the gearbox to the spindle is transmitted by chains through an intermediate shaft, and is taken up by a hand operated multi-plate clutch, which is automatically disengaged when a thread is completed. This clutch control lever also operates the collet mechanism, so that one movement only is required to grip the work in the collet and set the machine in motion.

The tool-post is carried on a slide on the saddle and it is the movement of this slide which controls the length of thread being cut. The tool-slide operates on rollers on a hardened and ground guide, which forms the top part of the saddle. The slide is actuated by a barrel cam in the apron, which, thrusting against a roller on the slide, causes the whole assembly to move along, at a rate determined by the change gears, to give the desired pitch of the thread. Drive to the slide is transmitted through gearing from the main spindle to the feed shaft and thence to the camshaft. One complete revolution of the cam completes one cycle of the cutting tool, 240 degrees of the cam periphery being used for traversing the slide during the cutting stroke and 120 degrees for the return stroke. At the end of the cut a recoil cam withdraws the tool automatically from the work without stopping or changing the direction of the spindle. The slide then returns to its starting position, automatically moves forward the set distance plus the cutting feed increment and begins the next cut. The machine is designed to give up to thirty-two passes per thread

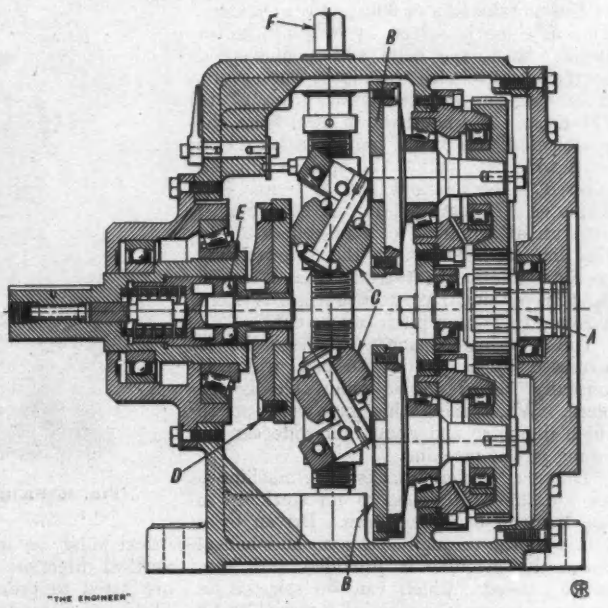


FIG. 34—VARIABLE SPEED UNIT—SENTINEL

and to cut up to eight threads per inch. The feed per cut and depth of thread, and the number of passes per thread are set by means of grouped handwheels on the apron of the saddle. This feed can be reduced, as cutting proceeds, down to as low as 0·0004in if very high finish is required.

Multi-start threads from two to twelve starts can be cut and when cutting these threads the feed operates after all starts have been cut. For example, with a six-start thread a cut is taken on each of the six threads before the feed operates, then the six threads are again cut, and so on, until the final depth is reached.

A variable-speed unit made by this company has many applications, both in the machine tool and other industries. For the standard model of this unit 1400 r.p.m. has been adopted as the basic driving speed, and with this is obtained an output speed which is infinitely variable between 275 and 1650 r.p.m. at constant power. We reproduce in Fig. 34 a drawing showing the general arrangement of the unit.

From the input shaft A drive is transmitted through gears to two discs B. A pair of conical rollers C are set between the two driving discs and a disc D coupled to the output shaft. These conical rollers are designed to transmit the drive to the single disc without slip, as the pressure of the disc on the rollers varies in proportion to the load applied to the driven shaft. This automatic pressure adjustment is obtained by the relative self-setting of two helical thrust surfaces, which have the balls E, interposed between them, connecting the driven shaft with its disc.

The desired speed ratio between the driving and driven shafts is obtained by movement of the conical rollers towards or away from the centre of the disc D, through the shaft F. All of the thrust loads imposed in the unit are carried by large ball or roller bearings and the whole of the mechanism runs in oil.

B. Elliott and Co., Ltd.

The equipment shown on the stands of B. Elliott and Co., Ltd., Victoria Road, London, N.W.10, includes a new "Empire" 7in lathe, which is built with two lengths of bed to take 40in or 60in between centres. This machine is driven by a 2 h.p. motor through twin vee belts and a nine-speed gearbox, which, with the sliding back gears, gives eighteen spindle speeds, from 27 to 775 r.p.m. A smooth final drive from the gearbox to the main spindle is provided by a wide, flat belt. The spindle runs on tapered roller bearings and is bored $\frac{15}{16}$in diameter. If required, it can be provided with an attachment to take collets up to 1in diameter. Through the screwcutting gearbox Whitworth threads from 2 to 56 threads per inch, or metric threads from 0·25mm to 7·5mm pitch can be cut.

The working capacity of the lathe is increased by a gap in the bed, which is normally closed by a removable bridge piece. When using this gap work up to $19\frac{1}{4}$in diameter and about 5in wide can be swung on the machine.

The new "Velox" hacksawing machine—see Fig. 35—is designed to cut stock up to 6in diameter or $5\frac{1}{2}$in square. Driven by a 1 h.p. motor through vee belts and helical gears, the machine is provided with two cutting speeds, which can be selected in accordance with the type of material to be cut.

The saw frame runs on wide, accurate guides designed to prevent saw twist during cutting and ensure parallel cuts through the material. The saw cuts on the draw stroke and is automatically lifted for the forward return stroke. Feed pressure on the saw is controlled by the adjustment of a plunger in the dashpot assembly. At the completion of a sawing operation the motor of the machine is automatically switched off. All shafts in this machine are mounted in ball

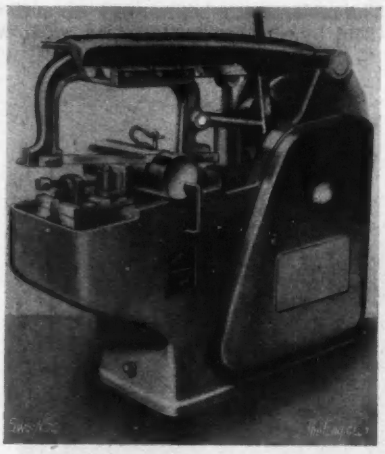


FIG. 35—HACKSAWING MACHINE—ELLIOTT

bearings, those of the crankpins being of the self-aligning type.

The latest design of "Excel" filing and sawing machine (Fig. 36) incorporates a number of very useful features for toolroom work. Its rectangular table is supported on two trunnion blocks on which it can be tilted up to 10 deg. in four directions. The table assembly is carried on a cylin-

FIG. 36—FILING MACHINE—ELLIOTT

drical pillar, on which it is adjustable in a vertical direction. Two adjustable steadies are fitted to prevent work chatter on the table. A pump driven from the main motor supplies air to a blower provided to disperse the swarf from the work.

The reciprocating frame is supported by one long bearing and two guide bars. It carries two chucks, the upper one being mounted in a sleeve, which can be adjusted to give the correct tension on a saw blade. Files having a tang and centre point may be used and these are held in compression in the frame. The frame is driven through gears and a vee belt by a $\frac{1}{2}$ h.p. motor, and four speeds, from 75 to 305 strokes per minute, are provided.

The company is also showing one of its latest "Speedax" 14in band sawing machines, which has four slow speeds from 130ft to 455ft per minute, and four high speeds, from 1800ft to 6050ft per minute. A range of lighter equipment displayed includes chucks, machine vices, pedestal and bench tool grinders, shearing machines, &c.

Samuel Osborn and Co., Ltd.

Space restrictions have made it impossible for Samuel Osborn and Co., Ltd., of Sheffield, to demonstrate the cutting power of its tool steels and tools on heavy-duty machines upon its own stand. For this reason it has adopted a novel method of showing not only the tools produced, but also the methods of manufacture.

The exhibit is in the form of a large revolving ring, on which are displayed the various tools which are produced by the company, and inside this ring are three panels. The first panel contains a model of an arc furnace melting shop showing a furnace melting, tapping steel into the ladle and making the ingot. The second panel shows these ingots being processed in a working model of a forge shop. The ingots are shown being forged into blooms and billets ready for further processing in a rolling mill depicted in the third panel, and consisting of a train of rolls in operation complete with all accessories.

Steel bars and blanks produced by the processes as shown in the panels are the raw materials for the various stages of the production of tools shown on the outer ring itself. The range of steels shown includes the "Mushet" high-speed steels, and subsequently improved grades, such as "S.O.B.V." cutting alloy, and "Super Mushet 723." The display includes twist drills, milling cutters, reamers, hobs, lathe tools, &c., which are made from this range of special steels.

Mond Nickel Company, Ltd.

The object of the exhibits of the Mond Nickel Company, Ltd., Grosvenor House, Park Lane, London, W.1, is to show the enhanced precision in machined tools achieved by the use of nickel alloys, and the services the company has to offer. It is pointed out that modern production methods, involving the use of more efficient cutting tools, higher machining speeds and simplified operation, coupled with the demand for precision of output, have led to the development of sturdier and more durable designs in machine tools. These conditions could not have been met without the availability of materials of construction capable of handling the higher unit stresses involved and sufficiently wear resistant to maintain the high accuracy and smoothness of operation required. Modern materials largely owe their superior qualities to their alloy content, and one of the most important of these alloys is nickel.

In one of three main sections into which this company's stand is divided are seven panels showing the properties on which precision in manufacture depends, and other sections deal with the publications available on nickel and the services available to industry.

A Seven-Day Journal

International Technical Congress in Cairo

At the invitation of the Egyptian Government the second International Technical Congress is to be held in Cairo from March 20 to 26, 1949. The arrangements for it are being made by the World Engineering Conference, which was established as a permanent organisation following the first International Technical Congress held in Paris in September, 1946. The main subject for discussion at next year's Congress will be "Raw Materials as an Industrial and Social Problem," and there are to be three sections studying "Industrial Raw Materials and their Rational Utilisation throughout the World," "The Social Aspect of Technical Development and of Raw Material Problems," and "The Problem of Water in the Middle East." The Cairo reception committee is to be presided over by His Excellency Hussein Said Bey, chairman of the Committee of Public Works of the Egyptian Parliament, and the Egyptian Agricultural and Industrial Exhibition will be taking place in Cairo during the time of the Congress. Visits to industrial plants and other places of particular interest are to be included in the Congress programme. Membership of the Congress is open to engineers of all countries, and application should be made before December 31, 1948, to the Egyptian National Committee of the World Engineering Conference, 3, rue Baehler, Cairo.

Conference of Ship Tank Superintendents

The fifth International Conference of Ship Tank Superintendents is to be held in London from September 13th to 17th, the headquarters being the offices of the British Shipbuilding Research Association, 5, Chesterfield Gardens, Curzon Street, W.1. The conference was initiated by Sir Charles Darwin, Director of the National Physical Laboratory, and may be regarded as a continuation of those held in various countries prior to the war. The programme opens on Monday, September 13th, with an evening reception for delegates and their ladies by the First Lord of the Admiralty, on behalf of H.M. Government, and on Tuesday, September 14th, the discussions at the technical sessions will deal with "Cavitation Tunnel Tests," introduced by Mr. R. W. L. Gawn, and "The Choice of Suitable Reynolds' Number for Model Propeller Experiments," introduced by Dr. J. F. Allan. For the ladies, a visit to Windsor is being arranged. On Wednesday morning, September 15th, Dr. K. S. M. Davidson will introduce a discussion on "The Use of Turbulence-Producing Devices in Model Experiments," and in the afternoon the Port of London Authority is providing a river cruise for the delegates and their ladies on the yacht "St. Katherine." Subjects for discussion on Thursday, September 16th, are "Skin Friction," introduced by Dr. F. H. Todd, and "Turbulence and Skin Friction." In the evening there will be a dinner given by the Institution of Naval Architects. The concluding day of the conference, Friday, September 17th, will be spent at the National Physical Laboratory at Teddington. Sir Charles Darwin will preside over the conference, the secretary of which is Mr. T. Corin, of the Ship Division of the National Physical Laboratory.

The National Coal Board's Summer School

A summer school, arranged by the National Coal Board, and attended by about 450 students drawn from every branch of the mining industry, was held at Oxford last week. The principal aim of the school, according to the National Coal Board, was that it should provide an opportunity for the free exchange of views between every branch and grade of the coal-mining industry, and the students therefore included area managers, pit managers and miners, as well as Coal Board officials. The opening address was given by Mr. Alfred Robens, Parliamentary Secretary to the Ministry of Fuel and Power, who spoke on "Coal in the National Economy." Other speakers during the week were Lord Balfour, Sir Geoffrey Vickers, Mr. L. H. H. Lowe, Sir Ernest W. Smith and Lord Hyndley. On Thursday of last week, a paper on "The First Principles of a National Production Plan," which had been prepared by Mr. E. H. Browne, was read by Mr. J. Latham. Mr. Browne is the National Coal Board's Chief Mining Engineer (Reconstruction and Planning), and in the course of his paper dealt, amongst other matters, with the interrelation of coal production, demand, distribution and quality. He suggested that, in the past, developments in the use of various forms of power and in the consumption of different qualities of coal had been determined far too much by artificialities. It must be the objective of the National Coal Board, the paper emphasised, to guide the country towards the most efficient use of energy.

Machine Tool Exhibition Inaugural Luncheon

At the inaugural luncheon of the Machine Tool and Engineering Exhibition at Olympia on Thursday, August 26, 1948, Mr. J. Holland Goddard, president of the Machine Tool Trades Association, welcomed a large gathering of guests from home and overseas. In the course of his speech Mr. Goddard said that the machine tool men of the world need not be too modest about the part they themselves play in the progress towards recovery. The great industrial era in Britain only became possible because of the contribution made by machine tool designers and makers. The early inventors of those mechanisms which transformed the face of Britain would have been completely frustrated but for those other inventors who gave to them the means of producing their mechanical marvels. What the machine tool men of the early eighteenth century did for Britain's industrialists, they are throughout the industrial world doing to-day for successors to those industrialists, upon whom rests the major responsibility for providing the world with its multifarious needs. In a subsequent speech, Mr. G. R. Strauss, Minister of Supply, dealt with the growth of the machine tool industry in this country, and the difficulties it now faces. He reminded his listeners that with many materials in short supply production must be maintained, British industries supplied and export markets enlarged. At the same time, development and research must be pursued to the utmost. To do those things exceptional exertions must be made by the machine tool and other industries, and the speaker promised all concerned the fullest possible support of the Ministry of Supply in their efforts.

Mechanisation of African Agriculture

According to a statement by the Colonial Office, the problems likely to be encountered in the mechanisation of African agriculture are to be studied by a mission which left this country by air for Uganda on Saturday last. Dr. J. R. Raeburn, of the Agricultural Economics Research Institute, Oxford, is leading the mission, and he is accompanied by Mr. J. W. Y. Higgs, lecturer in Agricultural Economics, Reading University, and Mr. R. K. Kerkham, of the Uganda Agricultural Service. The task of the mission is to make a systematic survey of the sociological, economic, agricultural and technical problems which need to be studied if mechanisation of agriculture in the Colonies is to develop along sound lines. Such a survey must include, amongst other things, the form of organisation required to achieve the best results, as, for example, whether mechanisation should be on a co-operative group or peasant basis, and the most profitable lines of future research into problems arising from mechanisation. The types of tractors and implements likely to be best suited to the differing African communities will have to be investigated, and the mission will also consider such questions as the technical training of African craftsmen. In addition to Uganda, the mission is to visit Tanganyika, Nyasaland and Nigeria, and expects to be away for about two months.

British Railways' Appointment

An announcement from British Railways says that Mr. James Briggs, M.I.C.E., has been appointed civil engineer in the London Midland Region in place of Mr. W. K. Wallace, who is retiring. Mr. Briggs, who is the eldest son of a former engineer-in-chief of the old Midland Railway, joined the chief engineer's Department of the Midland in 1908, and in 1912 became an assistant to the Midland's western divisional engineer. In the first World War, he served with the Royal Engineers and was engaged on military railway constructional work in France. He returned to the Midland Railway in 1919, and a year later he was appointed southern divisional engineer. Following the grouping of the railways, Mr. Briggs continued in a corresponding position on the L.M.S. system until 1928, when he was transferred to Bangor as district engineer, North Wales. In 1935 he became senior assistant (permanent way) to the chief engineer of the L.M.S., succeeding to the position of assistant engineer (permanent way) in 1937. In 1945, Mr. Briggs was appointed assistant engineer of the L.M.S., and last year was promoted to the post of assistant chief engineer.

Liverpool Street Central Line Station

London Transport has announced that work has been restarted on the scheme for reconstructing the Central Line station at Liverpool Street in order to provide better facilities for interchange between the Central and Metropolitan Lines and thus help to relieve the congestion at present experienced during peak hours. An additional booking hall, which is to be built beneath the road surface of Liverpool Street, will be connected by a bank of three escalators to the Central Line platforms, and stairways will be constructed to link this new booking hall with the Metropolitan Line station, whilst the existing Central Line booking hall will be connected to it by means of a subway. The new booking hall will be 110ft long and 40ft wide, and as it is to be constructed at a depth of 15ft below the road surface the work will involve the diversion of various electric cables and gas and water service pipes. The existing escalators between the Central Line platforms and the Eastern Region station concourse, and the facilities at present given by the subways from the Metropolitan Line to that station will not be affected by the new works, although the main Metropolitan Line booking hall is being redesigned as part of the general improvements. At the time the Central Line station at Liverpool Street was opened thirty-six years ago it was, of course, intended as a terminal station with the principal object of providing easy interchange with the L.N.E.R. main line station. When the eastward extension of the Central Line was decided upon, however, it was foreseen that the station, as originally built, would be inadequate to cater for the increased volume of traffic, and its reconstruction was regarded as an essential part of the 1935–1940 new works programme. Work was, in fact, well in hand at the outbreak of the war, and now that it has been restarted it is hoped that it will be completed in from two to two and a half years. Mr. P. Croom-Johnson, London Transport's chief engineer, is supervising the reconstruction work, for which Messrs. Mott Hay and Anderson are the consulting engineers, and Kinnear Moodie and Co., Ltd., the main contractors.

The Machine Tool and Engineering Exhibition

No. II—(*Continued from page 205, August 27th*)

TO those engineers who find it impossible to visit the Machine Tool and Engineering Exhibition at Olympia we offer our sincere sympathy, for never before has there been such an opportunity to see so vast and interesting a collection of machine tools and equipment in this country. What is more, the exhibitors themselves obviously take a delight in "showing the paces" of their equipment, and there is no shortage of efficient and practical demonstrators ready and willing to answer all questions. With but few exceptions the machines have been well arranged in the space available, and round each there is sufficient room to inspect their details in a fair measure of comfort.

It is perhaps appropriate that this exhibition of modern machine tools should include examples of the work of the early machine tool makers, and an interesting group of early British machines has been arranged between the galleries of the Grand Hall and the National Hall. Perhaps a larger and more comprehensive collection might have been assembled, but the equipment on view includes many items worthy of attention. This collection includes examples of the work of Maudslay, Wilkinson, Nasmyth, Whitworth and Bramah, all of whom are familiar to engineers for their work in the early development of machine tools. Maudslay's original models of his block-making machines, designed in conjunction with Brunel and Bentham; Bramah's hydraulic press and lock-making machines; a treadle lathe of about 1760, and thread rolling machines of 1870 and 1878, are all interesting examples of the workmanship of earlier days.

In the following article and the Supplement which accompanies this issue we continue our descriptions of some of the interesting machines to be seen at the exhibition.

Metropolitan-Vickers Electrical Company, Ltd.

The Metropolitan-Vickers Electrical Company, Trafford Park, Manchester, is exhibiting a considerable range of equipment for application to machine tool work, including various types of motors, contactor and electronic control gear, automatic contouring equipment, crack detector apparatus and lighting equipment.

A notable exhibit is the company's new automatic contouring equipment for reproducing irregular shapes in repetition machining. A general view of the equipment is shown in Figs. 19 and 20. In it, the motion of the tool is controlled by means of two small split-field d.c. motors, which drive the longitudinal and cross-slide screws of a lathe through suitable gearboxes. Coupled to each motor is a small tachometer generator, which produces a voltage proportional to its speed.

Mounted on the saddle of the lathe in a position convenient for the operator is a manual control unit, which embodies a directional bias control consisting of two specially wound continuously rotatable potentiometers on a common shaft, operated by a control knob. The potentiometers are arranged to give two voltage outputs which are directly proportional respectively to the components of the pointer direction, parallel with and at right angles to the bed of the lathe. These two voltages, together with feed-back voltages obtained from the tachometer generators, are fed to two hard-valve amplifiers, the amplified push-pull d.c. outputs of which energise the split-fields of the longitudinal and cross-slide feed motors respectively. By virtue of the velocity feedback from the tachometer generators, the longitudinal and cross-slide motors run with steady velocities directly proportional to the components of the direction of the pointer of the directional bias control parallel with and at right angles to the bed of the lathe. The toolpost of the lathe consequently moves in a direction parallel with the direction of the pointer of the directional bias control; hence the name given to this adjustment. The maximum speed with which the toolpost moves is adjusted by the operator.

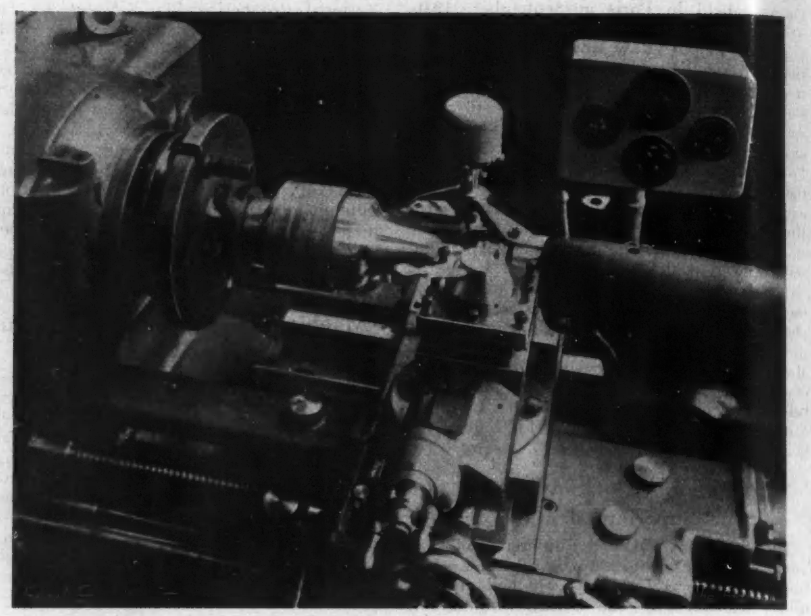


FIG. 19—CONTOURING EQUIPMENT ON A LATHE—METROPOLITAN-VICKERS

Mounted upon and moving with the cross slide of the lathe is a stylus-operated sensitive electro-magnetic device termed the "follower head." This device and its relationship to a master template, the profile of which it is required to reproduce, are clearly shown in Fig. 20. The master template is rigidly clamped at the rear of the lathe. The stylus or tracer point of the follower head is circular and capable of movement against built-in springs for a few thousandths of an inch in any direction in the horizontal plane. The function of the follower head is to resolve any deflection of the stylus into two voltages which are directly proportional to the components of the stylus deflection parallel with and at right angles to the bed of the lathe. These two voltages are fed in series with and in opposition to the corresponding two voltages from the directional bias control.

With the stylus out of contact with the template and therefore undeflected, the two output voltages from the follower head are zero, and the toolpost of the lathe—and hence the follower head (since both are carried by the cross slide)—move at constant speed in a direction parallel to the pointer of the directional bias control. By setting the directional bias control appropriately the stylus can be made to approach the template. When, however, the stylus contacts the template and is thereby deflected slightly, the resulting output voltages from the follower head oppose the corresponding voltages from the directional bias control and prevent the feed motors from developing any torque tending to drive the stylus further into the template. As a result the speeds of the two feed motors adjust themselves so that the stylus is carried smoothly along the profile of the template. The only attention required from the operator thereafter is adjustment of the directional bias control to ensure that the general directional bias of the equipment is always in a direction tending to feed the stylus into and never away from the template.

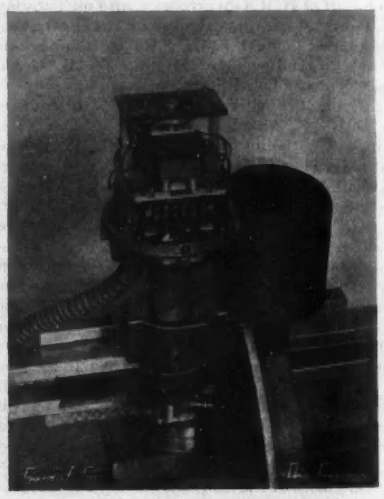


FIG. 20—CONTOURING FOLLOWER HEAD—METROPOLITAN-VICKERS

B. and S. Massey

During recent years several additions have been made to the wide variety of stamps

and hammers for which B. and S. Massey, Ltd., of Openshaw, Manchester, is so well known. Some of these new and improved machines are to be seen in operation on the firm's stand in the Grand Hall Annex.

This firm makes several sizes of friction screw presses with capacities of 70 to 320 tons in two types—for normal work and for high-speed work—and a 70-ton press of the

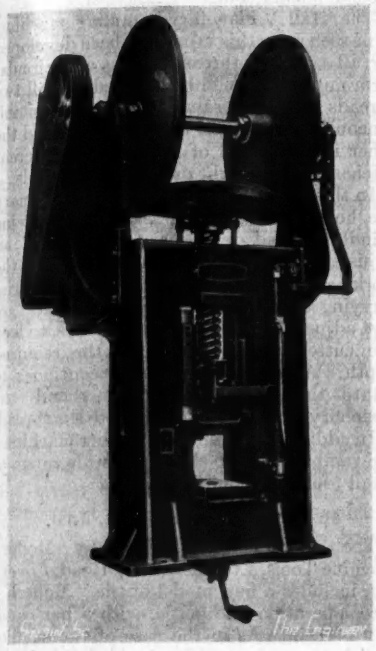


FIG. 21—FRICTION SCREW PRESS—MASSEY

high-speed type is included in the exhibits. This press (see Fig. 21) has a table 16½in by 10in, and its maximum stroke is 11½in. It is controlled by a hand lever, which may be swivelled to the most convenient position for the operator. An automatic brake actuated by a cam and roller mechanism arrests the ram as it reaches the top of the stroke, and a safety catch provides an additional safeguard against accidental lowering of the ram. Extraction of the finished pressings is facilitated by a foot-operated ejector.

In addition to several heavy machines, the lighter equipment on this stand includes the latest design of pneumatic hammer with slides, which combines guiding of the tup close down to the work with definite location of the anvil block in the base plate. These hammers incorporate single-blow mechanism and can be used for stamping in dies, as well as for forgings where the tup is subject to frequent side thrusts.

The anvil block is provided with a separate forged steel top which gives great strength, can be replaced when worn, and can be removed temporarily to enable work or tools of unusual size to be manipulated under the hammer. In these machines the crankshaft is mounted in two roller bearings, and is arranged so that it can readily be withdrawn with its bearings from the standard.

The ½ cwt spring power hammer we illustrate in Fig. 22 is the smallest of three sizes now being made in two types—one for general smithy work and the other, which runs at much higher speeds, for production work. In addition to the difference in speed the high-speed hammers are provided with wider palletts, thus giving extra surface to support special tools or to enable impressions to be cut in the palletts.

Each hammer is a self-contained unit, the drive being through vee ropes from a

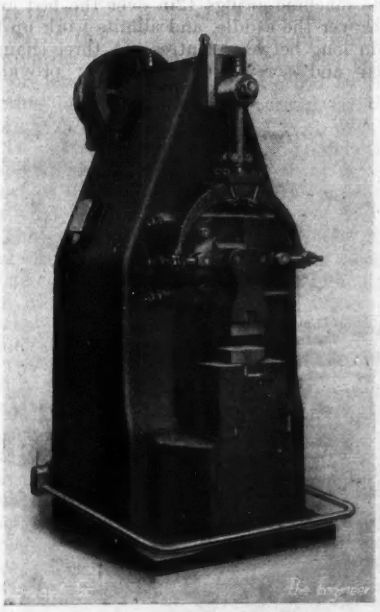


FIG. 22—½-CWT SPRING HAMMER—MASSEY

motor mounted inside the standard. The anvil block, which is cast in one piece with the frame, is fitted with a separate forged steel top, which is keyed and spigoted to the lower portion of the block.

Control is by means of a foot lever, and the force and speed of the blows may be varied by altering the position of the lever, full force blows at maximum speed being struck when the lever is in the lowest position. When the foot lever is released a brake comes into action, to bring the hammer to rest quickly. The length of the stroke can be varied by altering the throw of the crankshaft, and the height of the tup above the anvil pallett face can be readily adjusted by shortening or lengthening the connecting-rod. A machine-cut rack is employed for the adjustment of the stroke, and its position does not depend upon a frictional grip.

LORANT AND CO., LTD.

The principal exhibit of Lorant and Co., Ltd., 98-100, Croydon Road, London, S.E.20, is the "Universal Rindis," a basic machine, which, with the use of a number of accessory parts, can be arranged to perform the functions of a wide range of machine tools. For demonstration purposes it is shown in six forms—as a filing machine with a circular filing disc; a horizontal milling machine; a vertical milling machine, a slotter, a cutting-off machine fitted with a high-speed abrasive disc, or, alternatively, a cup wheel for grinding, and as an external or internal grinder, as shown in Fig. 23.

The basic machine consists of rigid cast box-form base, enclosing the main driving equipment. The drive is taken from a 1 h.p. heavy-duty, continuous rated motor through cone pulleys and gears, which give a range of eighteen spindle speeds from 65 to 2650 r.p.m. A compound slide table, with a surface 12½in long by 6½in wide, is set on a column, on which it is movable through a handwheel over a height of 6in. A motor-driven coolant pump and a low voltage lighting unit are built into the machine.

The makers point out that both the primary machine and its many accessories, have been designed and are built to close limits to ensure ease of attachment and give accuracy in operation. The simple yet effective arrangement of the basic elements of the machine can be seen in the illustrations.

This firm is also exhibiting for the first time a new portable, turbine-driven air

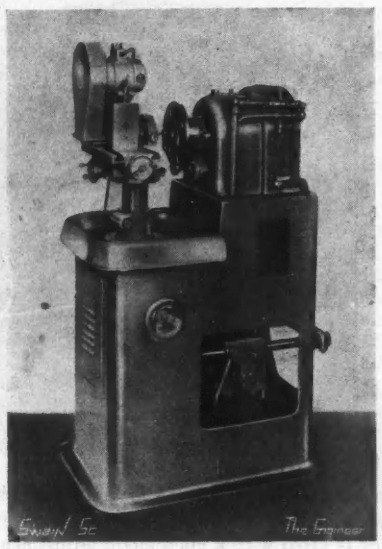


FIG. 23—"UNIVERSAL RINDIS" GRINDER—LORANT

grinder, running at speeds from 20,000 to 40,000 r.p.m., and a new trepanning tool, which is adjustable for cutting holes from 1½ to 4½in in diameter.

CHARLES CHURCHILL AND CO., LTD.

A number of interesting British and American machines are to be seen upon the stands occupied by Charles Churchill and Co., Ltd., of Coventry Road, South Yardley, Birmingham.

A Churchill-Redman 12in swing, semi-automatic hydraulic lathe has an infinitely variable range of cutting feeds and speeds, and all movements of its carriage, chuck and tailstock are hydraulically operated. Its bed, as can be seen in the illustration Fig. 24 has been built in two sections. The lower section houses and totally encloses the hydraulic unit and oil pump, together with the pressure release valve and four circuit valves. The upper bed has its ways inclined at an angle of 25 deg. towards the rear so that the resultant of the cutting forces is at right angles to the bedways. This arrangement also facilitates the disposal of chips, special provision for which is made at the rear of the machine.

The spindle is mounted on opposed pre-loaded taper roller bearings at the front and a large roller bearing at the rear. The intermediate shafts in the headstock are carried on ball bearings. Drive from the 15 h.p. main motor is taken by vee ropes through a combined multi-disc clutch and brake, which controls the starting and stopping of the spindle. The machine is fitted with a single-speed motor and headstock pick-off gears are used for varying the spindle speeds between 95 and 800 r.p.m. A hydraulic chucking cylinder is mounted at the rear of the spindle

and is connected by a draw-bar through the centre of the spindle to a three-jaw chuck mounted directly on the spindle flange. A hydraulically operated tailstock of the rotating centre type is operated by a pedal.

The feed of the carriage, which has a large bearing area and locates on the centre shears of the bedway, is entirely hydraulic and is infinitely variable between ½in and 12in per minute. The hydraulically operated tool slide is fitted with a micrometer adjustment.

In operation, on engagement of the hydraulic feed control lever, the tool is automatically fed into its preset depth. At this point the hydraulic carriage feed comes into effect, and, at the end of the machining traverse, the tool is automatically relieved and the carriage returned to its starting position under quick-power traverse.

A Churchill - Redman "Cub" lathe, for tools. Its all-geared headstock is driven by a 1 h.p. two-speed motor through vee ropes, there being twelve spindle speeds from 32 to 1000 r.p.m. Drive is transmitted through a multi-disc clutch, the control of which incorporates a quick-acting brake. The machine swings 12in over the bed and 8in over the saddle, and admits work up to 24in long between centres. A three-change feed and screw-cutting gearbox provides three feeds, with a choice of three threads for screw cutting without changing the wheels on the end train. With the wheels provided the range of feeds and threads is as follows :—Sliding, 0·0015in to 0·038in ; surfacing, 0·0003in to 0·0075in ; Whitworth and B.S.F. threads, two to forty-eight threads per inch ; metric threads, 0·25mm to 6·5mm pitch.

A new six-spindle "Conematic" automatic on this stand (Fig. 25) has a collet shown on the stand, presents a particularly clean and neat appearance, with its two fabricated base end members formed as enclosed cabinets. The headstock leg encloses the main motor and drive, and the tailstock leg incorporates a cupboard and two drawers capacity of 1in with a maximum stock feed of 6in. Driven by a 20–25 h.p. 1800 r.p.m. motor, the machine has fifty work spindle speeds of 220 to 4700 r.p.m. in a two-range gear transmission. It is fitted with six cross slides having dial controlled length of working stroke. For the first and second positions the cross slide total travel is 1⅞in, and for the remaining four positions 1⅝in, the slide working travel with a standard master cam being up to 0·70in. A long cylindrical main end-working tool slide has six full end-working positions accurately located from the work spindle axes, with sufficient clearance to swing standard die heads. It has a total travel of 5in, with a working travel of 1·7in with a standard, and up to 4in with a special, master cam.

The Hall "Planetary" milling machine, to be seen upon this stand, has been developed for all types of thread milling and circular form milling. It can be adapted to mill two threads on the same component simultaneously, one thread being external and the other internal, and of the same or different pitches of either right or left-hand threads.

In this machine the work is held stationary the hob or cutter being set on a revolving spindle carried in a head which has an adjustable eccentric motion in respect to the work axis. In operation, the eccentrics carrying the cutter spindle in the head are first adjusted, whilst the head rotates, to feed the cutter into the work to the required depth. As the eccentric body continues to rotate the cutter is carried round the periphery of the work to complete the thread.

In addition to a number of other machines, the company is also showing a wide range of small tools and equipment.

Modern Machine Tools, Ltd.

The equipment exhibited by Modern Machine Tools, Ltd., Maudslay Road, Coventry, includes a new model of the "Modern" three-operation automatic, with a bar capacity of 1¼in. As in the case of the smaller model, the new machine has been designed for the rapid production of parts required in limited quantities, and is arranged for quick and simple tooling.

An oil-grooving machine on the stand is suitable for producing all kinds of internal, external and face-type, single and multiple oil grooves. A division plate incorporated within the headstock allows the machine to be used also as a horizontal slotter or a splining machine. It can also be used for normal centre lathe work if required.

This machine (see Fig. 26) swings a diameter of 13¾in over the bed and 5¼in over the saddle, and it takes up to 24in between

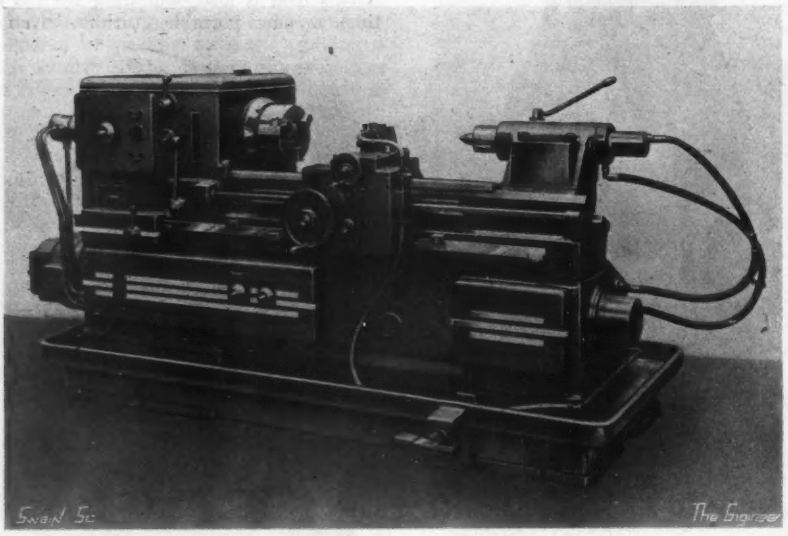


FIG. 24—HYDRAULIC LATHE—CHURCHILL

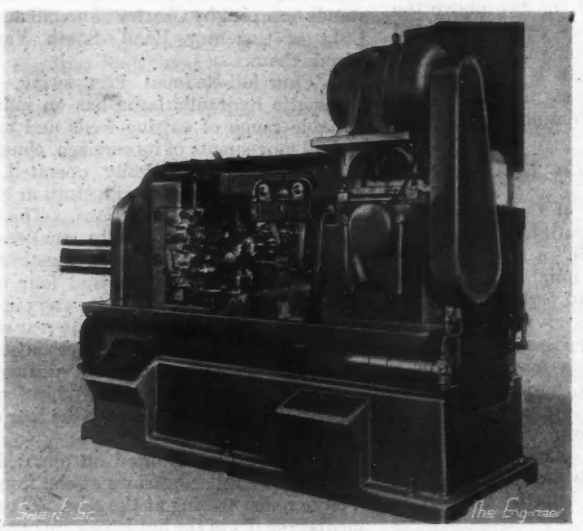


FIG. 25—"CONEMATIC" AUTOMATIC—CHURCHILL

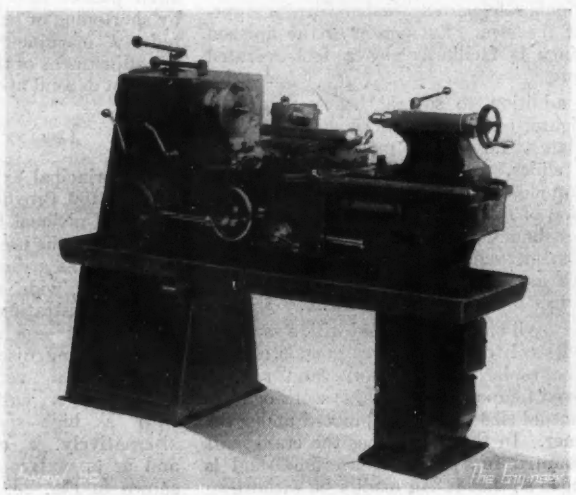


FIG. 26—OIL GROOVING MACHINE—M.M.T.

the centres. The all-geared headstock has four spindle speeds, from 57 to 170 r.p.m., and gearing for the crank motion to the saddle, which is also enclosed within the headstock, gives ratios of 1 to 1, 2 to 1, 3 to 1, and 4 to 1 of the spindle. The saddle, which is fitted with the usual cross slide and top slide, has also an independent automatic relieving slide, operated by a cam from a gearbox at the rear.

Reciprocating motion to the saddle, in a longitudinal direction, is provided by an adjustable crank on the front of the machine. Adjustment of stroke is accurately effected by means of a screw controlled nut in conjunction with a graduated scale.

The latest model of thread miller made by the company is designed for the rapid production of short threads up to 1¼in long. Both internal and external threads are cut on diameters up to 7in, in one revolution of the workpiece on the machine.

A useful inverted deep drilling machine, intended for deep hole boring, can also be adapted for fine boring operations. In this machine the feed is imparted to the work-holding fixture by an hydraulic cylinder and a rapid return movement is effected by pneumatic means.

David Brown Machine Tools, Ltd.

Some interesting new and completely redesigned gear-cutting plant is being shown by David Brown Machine Tools, Ltd., Sherborne Street, Manchester, 3. For many years this company has used the gear-shaving method for correcting large spur and helical gears to precision limits of tooth profile, tooth spacing and helix angle in its own gear-making works. As this method of gear finishing is very desirable for many types of small gear wheels, machines for gears up to 25in diameter have been developed. One of the new machines is to be seen on the firm's stand.

On this gear shaver the axis of the work spindle is arranged vertically in order to simplify the mounting of larger sizes of gears, from about 10in to 25in diameter, which can be well supported on cylindrical stands bolted to the table. In the machine the shaving cutter is traversed vertically along an axis inclined slightly to that of the work. An automatic tooth-relieving mechanism carried on the cutter slide enables gear teeth to be crowned, tapered or thinned down at the ends as required, by feeding the cutter deeper into mesh with the work at predetermined positions governed by the setting of adjustable cams carried on the upright of the machine.

The cutter spindle has a brake for the application of torque to resist rotary movement of the cutter when using the machine for single-sided shaving.

The cutter has automatic infeed at the end of each cycle of traverse, and by means of an automatic timing device the machine can be set for a predetermined number of cycles to finish a gear, at the end of which the machine stops.

The new "M.T. 15" hobbing machine, illustrated in Fig. 27, is the smallest moving table machine made by the firm. It is designed to cut gears up to 15in diameter and 5 d.p. maximum pitch. The hob slide has a vertical traverse of 10in, the maximum axial distance between the hob and the work being 11in. Hobs up to 3½in diameter and 4in long can be accommodated, and a hob speed range from 40 to 200 r.p.m. is available.

On this machine conventional or "climb" hobbing can be effected without need for adjustment, while quick power traverse is provided for the hob slide and table. In the standard hob slide, of normal design, hardened and profile-ground single helical gears are used for the hob spindle final drive. An interchangeable universal traversing hob slide with tangential feed, which is available, can be swivelled 360 degrees for the production of both 90 deg. and angle worm gears. Spur and helical gears within a slightly restricted range can also be cut with this attachment.

The dividing wormwheel is cut in position with the table, which is spigotted in the cradle on a large diameter flat, annular seating, with axial location given by a tapered bearing. The accurately ground dividing worm is supported in adjustable bearings, reducing backlash to a minimum. Slideways are formed on the underside of the work cradle, which can be traversed along ways in the bed by means of a ground screw and nut.

All the gears for the drives to the hob and table, including the differential, are housed in one gearbox, an arrangement which allows the unit to be built and tested before assembly in the bed of the machine. Main drive is taken through a worm and wheel from a motor flange-mounted on the bed. The speed, indexing, spiralling and feed change gears mounted in this one unit are all accessible through openings in the bed.

William Asquith, Ltd.

A new radial drilling machine which has been introduced by William Asquith, Ltd., of Halifax, incorporates many interesting features of design and operation. Two sizes of the new machine are exhibited, one having a maximum radius of 6ft 3in from the centre of the spindle to the centre of the column, and the other a maximum radius of 4ft 6in. The larger machine is designed to drill holes up to 3in diameter from the solid in steel and 3½in in cast iron, and the smaller machine 2in in steel and 3in in cast iron. We reproduce a photograph of the smaller machine in Fig. 28.

These machines have an infinitely variable spindle speed from 70 to 3500 r.p.m., which is applicable over the whole available range and when desired the speed can be varied during actual drilling. The speed range is divided into six groups, any of which can be brought into operation immediately by the operation of a gear-change lever. With the type of control fitted effortless changes

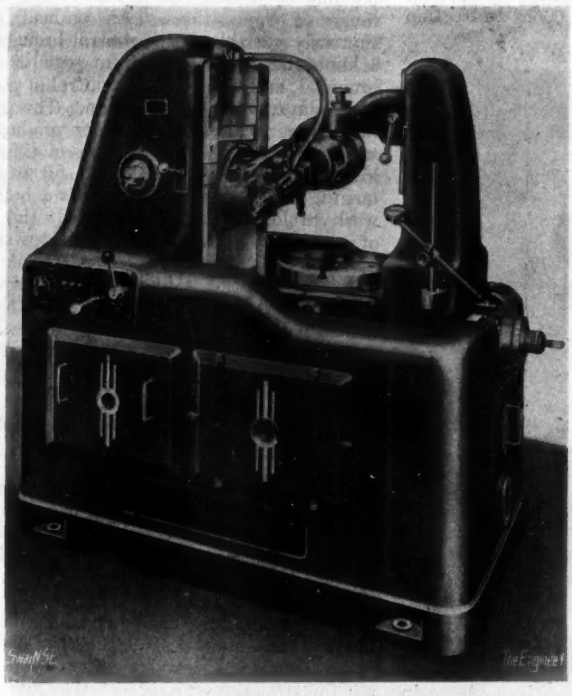


FIG. 27—GEAR HOBBING MACHINE—DAVID BROWN

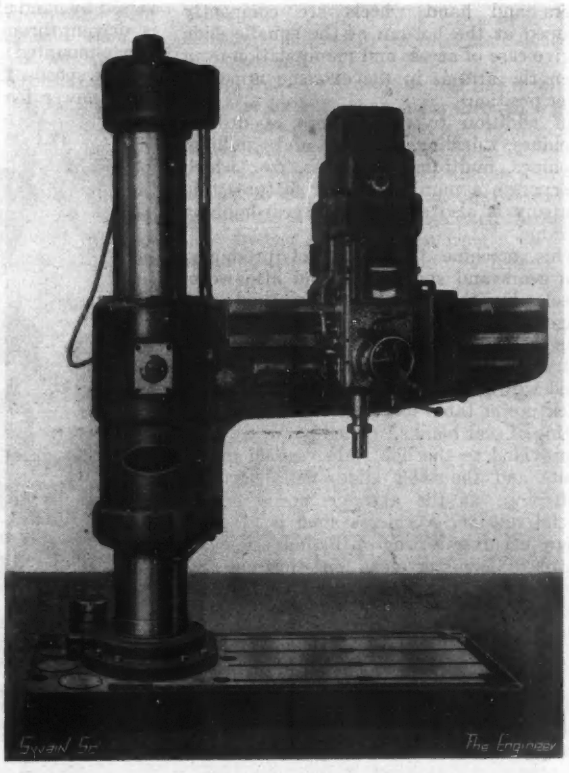


FIG. 28—RADIAL DRILL—ASQUITH

can be made without clashing of gears, and the main driving motor is automatically cut out during changing to start up again when the change is completed.

Final engagement of the power feed to the spindle is effected through pivoted levers mounted on a rack shaft. These controls are also used for quick hand traverse of the spindle when the power feed is disengaged by the action of a separate lever. The arrangement is such that the pivoted levers can be used for the sensitive spindle feed.

Spindle feed changes are obtained by means of small hand wheel on the left of the slide, the required rate of feed being selected with reference to the figures which appear in an aperture adjacent to the wheel. A trip dial graduated in $^{1}/_{32}$in can be set to disengage the spindle feed at any point in its travel.

A new form of speed selector and indicator, mounted centrally at the front of the slide, enables the appropriate speed for the diameter of hole and material being drilled to be instantly selected and applied. This indicator registers the exact speed at which the spindle is running, and the recommended cutting speeds for a variety of materials are indicated at the top of the device.

A single control lever operates the stop, start and reverse of the spindle, and the elevating and lowering of the arm. The direction of movement of this lever corresponds with that of the desired operation. This lever must be held in position when elevating and lowering the arm; the motion stops when hand pressure is released. An interlocking system prevents the arm-elevating mechanism from being engaged when the arm is locked on the pillar.

As can be seen from the illustration, all levers and hand wheels are compactly grouped at the bottom of the spindle slide to give ease of access and manipulation even when the arm is in the extreme upper or lower position.

In addition to other types of drilling machines, drilling, boring and milling, machines, multi-unit machines, &c., which incorporate a number of new features, the company is also exhibiting a gear-hobbing machine.

This machine is capable of producing spur gears and spiral gears and also worm wheels by the radial feed method, the tangential feed method, or a combination of both methods, i.e., roughing with radial and finishing with tangential feed. It is fitted with simplified directional control and quick power table rotation, to facilitate the setting of gear blanks. Quick power traverse is provided to the hob slide vertical movements and the table slide, with electrical limit trips at the extreme positions. A special rule and vernier system is fitted to ensure accurate setting of the hob and table centres. Dividing gear on the machine provides for hobbing numbers of teeth within the range from 8 to 517, and it accommodates hobs up to 4¾in in diameter.

Midgley and Sutcliffe, Ltd.

The milling machines exhibited by Midgley and Sutcliffe, Ltd., of Hunslet, Leeds, include a new machine of large capacity, which has recently been developed. This machine has a table with a working surface of 46in by 10½in, arranged for power feeds in all directions, and quick power traverse of 100in per minute longitudinally and crosswise and 50in per minute vertically. It has sixteen spindle speeds, from 30 to 700 r.p.m., and twelve feeds of 7½in to 20in per minute.

The radial drilling machines on the stand include one of the non-elevating arm type, illustrated in Fig. 29. These machines are made in two sizes, of 36in and 46in radius, either with elevating tables of the rack and pinion operated type as illustrated, or of the swivelling type. The arm is a substantial

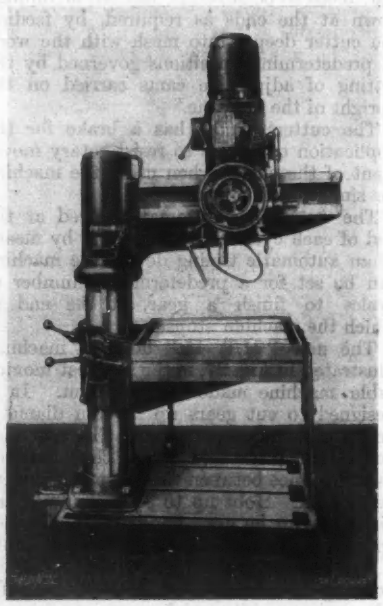


Fig. 29—Radial Drill—Midgley and Sutcliffe

box casting and is arranged to swing completely round the column on ball and roller bearings. The head assembly is traversed by hand along the arm and the spindle is driven through a gearbox by a 2 h.p. flange-mounted motor. There are nine spindle speeds, from 100 to 1500 r.p.m., with three power feeds from 0·005in to 0·015in

Fig. 30—"Hyspeedmil" Attachment—Midgley and Sutcliffe

per revolution. An automatic depth trip on the head can be set to disengage the spindle feed at any predetermined depth, and a sensitive feed lever is also fitted.

A very useful attachment for horizontal milling machines, the "Hyspeedmil," is also exhibited. This attachment (see Fig. 30) is mounted on a rigid cradle on which it can be quickly and easily fitted on most makes of horizontal milling machines, to facilitate precision milling, drilling and boring. It is fully universal and can be swivelled 360 deg. on two planes in respect to the work. The attachment is made in two types each driven by a ½ h.p. motor through six-step vee belt pulleys. One model, fitted with a back gear, has eight spindle speeds, ranging from 130 to 4100 r.p.m., and the other, without a back gear, has six speeds, from 400 to 4100 r.p.m.

The spindle, which has a No. 3 Morse taper bore and a driving slot for end mills and collets, has a hand-operated traverse of 2½in.

Philips Electrical, Ltd.

Together with its very useful range of magnetic filters Philips Electrical, Ltd., Century House, Shaftesbury Avenue, London, W.C.2, is showing its new model of magnetic clarifier. This machine consists essentially of a small restricted channel into which contaminated coolant is gravity fed, and then flows past a slowly revolving aluminium disc, driven by a small electric motor. Near its periphery this disc carries a series of very powerful permanent magnets which, as they pass through the fluid, collect the ferrous sludge suspended in it and lift it out of the tank. As they emerge from the tank the magnets are cleaned by wipers which sweep the sludge via a chute into the sludge containers. The filtered coolant then passes back to the grinding or honing machine.

A radio-frequency generator demonstrated on this stand has been specially designed for use on small hard and soft soldering work, "spot" heating and local hardening of small components. It has a continuously rated output of 2·5kW at the terminals. Features of this instrument are flexibility and easy adaptability to the job. A six-position matching control switch makes it possible to obtain full power over a wide range of applications. An on-load continuously variable power control brought to a knob and scale on the front panel is also provided, and gives smooth control of power from almost zero to maximum. The generator is particularly suitable for production work where small batches of jobs of different kinds have to be treated, and for experimental work. A useful feature is a built-in work table, 42in off the ground, the top of which is of heat-resistant asbestos sheet material. Alternative output terminals are provided on the side of the generator. The power consumption of the set is 5kVA at 0·5 power factor, and it is suitable for a single-phase a.c. mains supply at 200V–250V.

Weatherley Oilgear, Ltd.

The products of Weatherley Oilgear, Ltd., of Stockport, are broadly divided into three main classes: broaching, plastic and sheet metal working plant. In addition to making an extensive range of standard machines, this firm designs and builds a large number of special-purpose machines, all of which make use of the well-known "Oilgear" hydraulic power unit.

Two horizontal broaching machines on this firm's stand—one with a capacity of 6000 lb and a stroke of 36in, and one of 50,000 lb and a 64in stroke—are representative types of this range of equipment. The adjoining "Cyclematic" vertical broaching machine, which we illustrate in Fig. 31, has a normal pulling capacity of 30,000 lb and a peak capacity of 45,000 lb. Capable of taking broaches between 32in and 60in long, it has an adjustable stroke from 20in to 48in, with an infinitely variable cutting speed from 4ft to 30ft per minute. In these machines the

broach is rigidly held at both ends during the operation, whilst the work table and components travel upwards during the

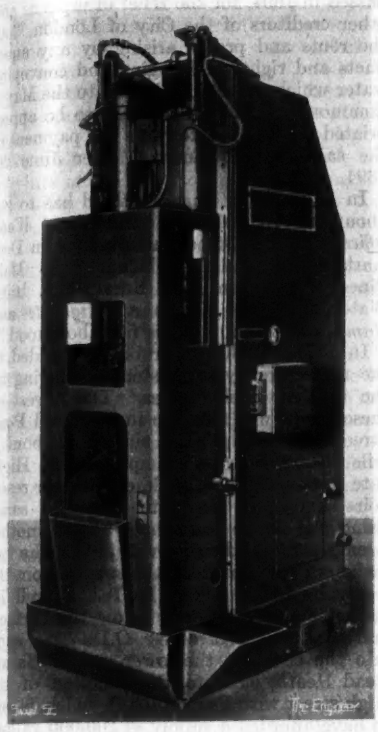


FIG. 31—BROACHING MACHINE—WEATHERLEY

cutting cycle. A number of broaches can be set in these machines to permit simultaneous operation on a number of components.

Among the plastics machines to be seen is the 200-ton compression moulder, shown in Fig. 32. This machine has an all-steel welded frame and the working space is arranged centrally between the frame uprights. It has a platen area of 36in by 21in and the daylight between the crosshead face and the platen face is 42in. For mould heating purposes includes means for automatic mould breathing. A fixed cover is fitted at the rear of the machine, whilst the front operating guard to the working area is interlocked with the machine controls.

A hydraulically operated bottom ejector on the press has a maximum stroke of 8in and

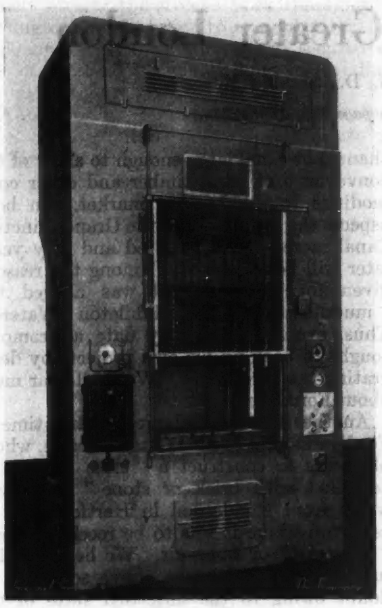


FIG. 32—MOULDING MACHINE—WEATHERLEY

is fitted with an adjustable stop and interlocked with the main ram movement. Four top ejector rods are fitted and each is threaded to provide means of adjustment. The ejector capacity up is 14 tons and down 7 tons.

H. W. WARD AND CO., LTD.

For very many years H. W. Ward and Co., Ltd., of Selly Oak, Birmingham, has specialised in the manufacture of capstan and turret lathes, and as might well be expected, an interesting range of these

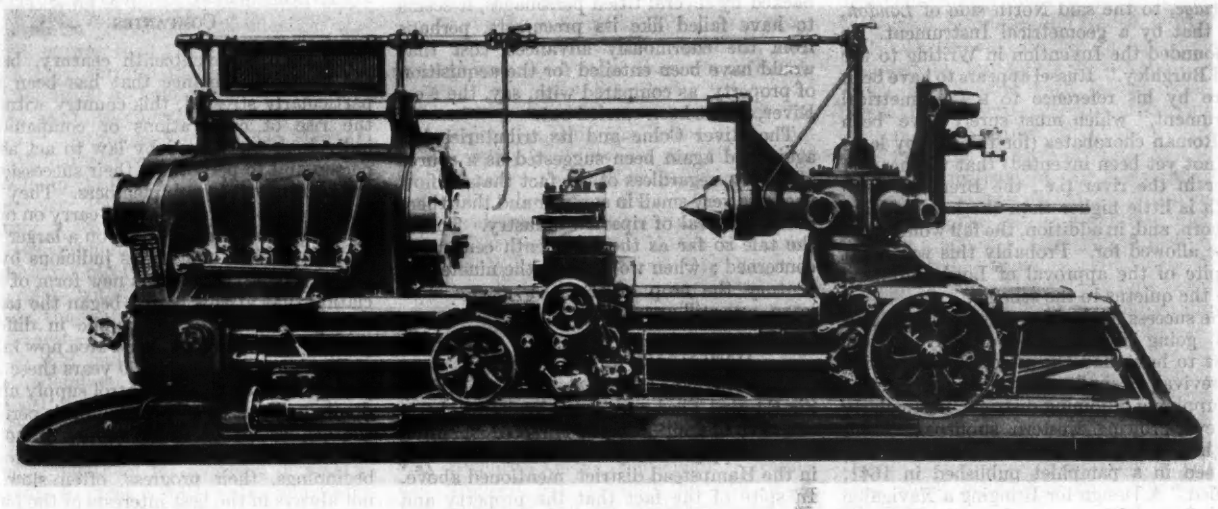


FIG. 33—COMBINATION TURRET LATHE—WARD

plug-in electrical connections are provided, together with means of accurate temperature regulation.

The control system of the machine is designed for automatic cycle operation and machines is to be seen upon this firm's stand.

The largest machine exhibited is the No. 16 combination turret lathe illustrated in Fig. 33. This machine has a spindle bored 8½in diameter and can swing work up to 25in over the saddle or 35in over the bed.

The all-geared single pulley headstock of the machine gives sixteen spindle speeds, from 7 to 225 r.p.m. in each direction, with a normal pulley working speed of 400 r.p.m. Spindle speed changes are effected by sliding gears, the mechanism being so designed that all sliding gear motions are carried out under "no load" conditions. Only one friction clutch, situated on the main pulley, is employed, and it is automatically disengaged before speed changing is effected. This clutch consists of two cones having metal to metal contact, and is spring-loaded, so that it is always in full engagement except at the actual moment of speed changing.

An overhead pilot bar is mounted on a double support on the headstock casting to give the high degree of rigidity which is required when removing metal at high speed with coarse feeds.

The feed gearbox is driven by an enclosed train of gears from the end of the spindle and provides motion to the feed shaft and the leadscrew. It gives the saddle forty-eight reversible automatic sliding and surfacing feeds in three groups, covering a range of 5 to 656 revolutions of the spindle per inch of traverse. Saddle screw cutting motion is obtained through a detachable leadscrew and nut. The leader drive from the gearbox allows the rotation to be altered as required in the ratios of 1, 2 or 4 to 1, and it is possible to cut three different pitches with each leader. A feature of the chasing saddle is the quick withdraw motion connecting the cross slide to the leader nut, so that both operate simultaneously and the tool is withdrawn from the work as the nut is withdrawn from the leadscrew. Quick power traverse in both directions is fitted to the intermediate saddle and cross slide.

The hexagon turret saddle has a similar range of feeds to the saddle through a gearbox in its apron. It is indexed by means of a vertical taper plunger operated by a conveniently situated lever and is provided with both hand and power means of rotation. Automatic rotation is transmitted through a light friction clutch driven from a constant speed shaft situated along the rear of the bed. By means of a quick power traverse, which operates in both directions, the turret can be quickly and easily moved along the bed of the machine.

The bed of the machine is a semi-steel

casting with a nickel-chrome content to give a good wearing surface. It has fixed covers made from channel section stainless steel and cored passages of similar shape provided through each saddle allow of their free movement without interference from the covers. No part of the bed is exposed and this feature, combined with automatic saddle lubrication on the ways, ensures a long life to the bearing portions of the bed.

(To be continued)

Water Supply of Greater London

By H. W. DICKINSON, D.Eng., M.I.Mech.E.

No. IX—*(Continued from page 208, August 27th)*

Water Supply Schemes That Failed

The supply of water to London throughout its whole history has been effected in the way dear to the English temperament: not by forecasting needs, but by ambling along till one gets to the stile and then being faced with the necessity of surmounting it. This is evidenced by what has been said already with reference to the conduit period and to the early period of riverside pumping. This is not to deny that supply was continually the occasion of solicitude over a long period of years on the part of far-seeing citizens, whom as we have seen, gave of their substance to ensure that a communal supply should be forthcoming. True, each mode of supply in its day had the appearance of meeting all needs; in particular the New River supply, set against the requirements of the time must have seemed to be a final solution. However, London has never stood still, and planning and scheming has always had its attractions.

We must now refer to a scheme as ambitious as that of the New River, but which had resulted in failure. This, which was a counterpart of that of the New River, only of earlier date, has already been mentioned, the source being from the west instead of from the north. We owe our knowledge of this scheme to Strype, who says :[39] "Before this New River was thus brought for the Supply of the City, the Projecting for the Conveniency of water from the *North* side of the City was not out of the heads of the Citizens. For about the year Fifteen Hundred Eighty and odd (as I conceive it) there was one *Russel* who propounded to bring it from Iselworth, viz. the River of *Uxbridge*, to the said North side of *London*, and that by a geometrical Instrument. He propounded the Invention in Writing to the Lord Burghley." Russel appears to have been aware by his reference to a "geometrical instrument," which must surely have been the Roman chorobates (for the dumpy level had not yet been invented) that the head of water in the river (i.e., the Brent) at Isleworth is little higher than the level of, say, Holborn, and, in addition, the fall would have to be allowed for. Probably this was what in spite of the approval of Lord Burghley, gave the quietus to the scheme.

The success of the New River, after it had been going for some twenty-five years, seems to have had the effect of stimulating the revival of similar long-distance schemes for supplying adjoining districts, particularly the ever-growing western suburbs. There was the scheme of Sir Edward Ford (1605–72), outlined in a pamphlet published in 1641, entitled "A Design for Bringing a Navigable River from Rickmansworth to St. Gyles in the Field; the Benefits of it declared and the Objections against it answered." While his main aim was to afford a supply of water to London, his intention was to make the channel or canal large enough to allow of the conveyance of corn, timber and other commodities to the London market. In both aspects the analogy with the Grand Junction Canal more than a hundred and fifty years later will be remarked. Among the reasons given for this proposal was alleged the "muddiness of the Middleton Waters." Thus, even at this early date a promoter sought to back up his own projects by denigrating the New River. We shall hear more about Ford later.

Another scheme of about the same time as Ford's was that of Sir Walter Roberts, whose plan was to construct a "close conduit or aqueduct with brick or stone" to convey water from Hoddesdon in Hertfordshire to Islington where it was to be received into a "conserve" or reservoir. We hear nothing further of either of the above schemes, no doubt owing to the unsettled state of the country, which was in the throes of the Civil Wars, and hence the lack of financial support. Myddelton had been more fortunate in point of time and in the support he had received!

We now pass to another project, that of "The Company for bringing water from St. Albans (i.e., the River Colne) to London and Westminster," in 1721, which had for its object the supplies of London and Westminster with water from the rivers Colne, Gade, Bulborne, Chesham Water and Lee. This was in the South Sea Bubble period of wild speculation, and that may have had something to do with its promotion. The petitioners actually got as far as a Bill before Parliament in the Session, George I, but the Bill was rejected. Although the scheme was backed by several titled personages, it seems to have failed like its precursors, perhaps from the enormously advanced cost that would have been entailed for the acquisition of property, as compared with, say, the New River, had it been carried out.

The River Colne and its tributaries has again and again been suggested as a source of supply, regardless of the fact that its flow becomes very small in summer and that there is a great deal of riparian industry. This is the tale so far as the eighteenth century is concerned; when we come to the nineteenth century the crop of schemes, as we shall learn, was still greater.

Hampstead Water Company

It was perhaps the failure of the schemes of Sir Edward Ford and of Sir Walter Roberts to arrive at fruition that redirected attention to the supply already established since 1590 in the Hampstead district, mentioned above. In spite of the fact that the property and management of the water works were vested in the Corporation of the City, yet in 1692 the privileges of obtaining and supplying water from these sources was conveyed to private individuals, who were incorporated under the title of the Hampstead Water Company, which was destined to have a long but uneventful career. By the way, as an offset to this ill-advised surrender of privileges on the part of the City, it may be noted that by a clause in an Act of Parliament (5 and 6, Wm. and Mary, cap 10), passed in 1694, for the relief of orphans and other creditors of the City of London, "all the rents and profits arising by any aqueducts and rights of bringing and conveying water which do or shall belong to the Mayor Commonality and Citizens are to be appropriated and applied towards the payment of the said interest money," after June 20, 1694.

In 1739 this is what Maitland has to say about the company: "*Hampstead Water Office.*—To this Office which is kept in Denmark-street, St. Giles's belong Two Main Pipes of a Seven Inch Bore which bring Water from the Ponds at *Highgate* and *Hampstead* to supply this neighbourhood."

In 1777, another reservoir was added to the three already in existence, bringing up the area to twelve acres. The lowest of these ponds was filled up in 1855 and Pond Street now occupies its site. At about a mile distant between Hampstead and Highgate in the Vale of Health, eight other reservoirs, known as Highgate Ponds—a series rising one above the other—added another twenty acres to the reservoir area. The two mains, of 7in bore, took the supply from the reservoirs to St. Giles. In 1833 a well 7ft diameter and 330ft deep below the surface, and well top 23ft above O.D., was sunk into the chalk at the lower end of Hampstead Heath, close to the junction of the High street with Payton Road, which, is said to have afforded a supply of 200,000 gallons of water per day. In 1835 a steam engine was put down to raise water to the village of Hampstead, where the want of a regular supply, especially in dry seasons, had long been experienced. Besides this, the company supplied Kentish Town and Camden Town, and from these ponds, as recently as 1813, domestic water was supplied to parts of Tottenham Court Road. The company was bought out by the New River in 1855. The yield of the well gradually fell off to about 8000 gallons per hour. The well water was considered unfit for human consumption but was supplied to Smithfield Cattle Market till 1936, when the well was finally disused.

Establishment of Water Supply Companies

During the seventeenth century, besides the technical advance that has been more particularly stressed, this country witnessed the rise of corporations or companies of individuals authorised by law to act as one person and to perpetuate their succession by the admission of fresh members. They were the means found necessary to carry on operations, especially in industry, on a larger scale than is possible or perhaps judicious by one person alone. It was this new form of association that at this period began the task of supplying water to the public in different parts of the widely extended area now known as London. For nearly 250 years these companies were destined to control supply and to dominate the scene. It is upon this period in the history of the water supply of London that we now enter. We shall deal with their beginnings, their progress, often slow and not always in the best interests of the public, their rivalries with one another, their amalgamations and their eventual supersession by a single authority.

The period of control by the water companies coincided roughly with the rise and the development to its zenith of pumping by steam power. Such development went

[39] Stowe's "Survey," Strype's Ed., 1720, Vol. I. page 26.

on simultaneously with all the companies; hence, although the history of each company will be mentioned separately, a cross-section of what took place in steam engine practice all along the line will be given. The companies were served by a devoted band of civil engineers, some of whose names are known even to the public, although most of them were "back room boys"; we can say, in fact, that their names are inscribed on the pages of the history of the steam engine.

We shall deal in the first place with the activities of the water companies during the time when they employed animals, water-wheels, tide-mills and windmills for raising their water, and then continue their history, adding that of later companies, which were established after the steam engine had displaced all other sources of power.

York Buildings Company

The earliest of the water companies to be formed was that known for short as the York Buildings Company, and of all the corporations established to supply London with water, it was the one which had the most chequered career, nay, even a romantic one.

During the Stuart and Restoration periods the spread of London westward joining up with Westminster and the increase of population both had the effect of causing a growing demand for water supplies in that area. The advance in technical knowledge during the period, especially after the Civil Wars, led to a blossoming forth of a number of schemes for raising water. In the case of the York Buildings Company we have to seek its first inception as far back as 1664. On May 16th of that year there was submitted to the King the "Petition of Frans. Williamson and Ralph Wayne to the King for leave to convey to the inhabitants of Piccadilly, St. James's Fields, Haymarket and the neighbourhood, water from springs which they have found near, they compounding with the inhabitants at reasonable rates, on account of the great expense they have been at in their new invention of an engine which, by perpetual motion, will drain levels, or mines though 50 fathoms deep, for which they have already a patent." The patent in question, No. 135, dated March 12, 1663, had been granted to Wayne and was for "his invention of an engine to drain water out of mines"; as no specification was enrolled, as was then the ordinary practice, we can only surmise that it was a water-wheel actuating a chain pump or a chain of buckets, as at other places; by "perpetual" he meant continuous motion. On May 31, 1664, Williamson and Wayne agreed with Sir William Pulteney for the use of the springs near Piccadilly and on June 25th following, a warrant was issued authorising these two promoters at a rental of 6s. 8d. per annum "receiving such profits as they agree upon with the inhabitants."[40] Apparently the promoters did not succeed in their project—they certainly would not have done so if it had been a perpetual motion as we understand it. Wayne, however, did not desist, for nine years later, on May 7, 1675, letters patent under the Great Seal were granted to Ralph Bucknall and Wayne, "empowering them for a period of ninety-nine years to erect a waterworks and water house near the river of Thames upon part of the grounds of York House, or York House garden, and to dig and lay ponds, pipes and cisterns for the purpose of supplying the inhabitants of St. James's Fields and Piccadilly with water at reasonable rents." York House was on the south side of the Strand close to the river, and the estate had passed through numerous hands, having been sold eventually, in 1672, for £30,000 and opened out for building purposes. The waterworks was an edifice with a high wooden tower. The site of this "waterhouse" was on the north bank of the Thames, between it and the Strand, at the bottom of the present Villiers Street; the street "York Buildings," turning out of 14, John Street, to-day recalls the spot. Evidently Wayne had secured a plot of the land for the purpose of erecting his water tower.

Water was led from the river at high water by a channel furnished with sluices into a

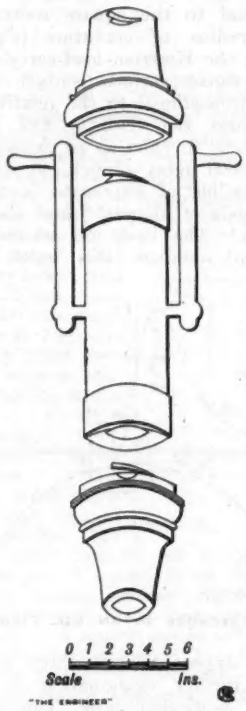


FIG. 38—NEALE'S PUMP, 1675

reservoir, whence it was pumped by horses-power into a cistern on the top of the tower situated over the reservoir; thence it was distributed through elm pipes, laid in the streets, to the customers. We do not know of what the pumping plant consisted, possibly it resembled either Bulmer's or Ford's horse-mills already described.

The plant did not last long, however, for in 1690 the building was burnt down, but as the supply had proved a financial success and a boon to the inhabitants, it was determined to rebuild the plant. To do so it was decided to form a company for which, as was then obligatory, an Act of Parliament (2 William and Mary, Cap. 24) was sought and obtained, incorporating the proprietors under the title of "The Governor and Company of Undertakers for raising the Thames Water in York Buildings." The proprietors at this time were Ralph Bucknall, Esquire; Sir William Thomson, Kt., Sergeant at Law; Sir John Bucknall, Kt.; William Hall, William Green, John Tompkins and Richard Petty, gentleman. Wayne had dropped out, possibly he was dead. The Governor and six Assistants were to carry on the concern. The water tower that was erected was quite a landmark; it is represented in an engraving of the eighteenth century but as it discloses no technical information it is not reproduced. The area supplied was Piccadilly, Whitehall, Covent Garden and the intervening streets. The number of houses supplied was about 2700. The rent charged was 25s. per house per annum.

During the reign of good Queen Anne we are to surmise that the horses kept the gin creaking and groaning, slowly filling the cisterns, and the inhabitants benefiting by the supply. However, great changes affecting the undertaking were now about to take place, not only on the technical side, but in consequence of political events. The technical one was the installation there by Thomas Savery, about 1712–13, of one of his "fire engines"; the political events were the death of Queen Anne, August 1, 1714, the consequent Hanoverian succession, and the Jacobite rebellion of 1715. We shall revert to these events when we come to the era of the introduction of steam power.

Shadwell Waterworks

During the seventeenth century London had extended not only westwards in the Westminster direction, but also eastwards, beyond the Tower to Limehouse, in other words, to an area beyond that served by either London Bridge Water Works or the New River. No adequate supply except from the Thames was available. Shadwell was just the spot for a riverside waterworks similar to that at Broken Wharf and at York Buildings for supplying water under pressure. It was this need that influenced the establishment of the waterworks here but incidentally we can say that it owed its origin largely to the inventive talent devoted to pumping appliances that was so marked a feature of the Restoration period.

The works were begun by Thomas Neale, groom porter to Charles II (the groom porter was the official who had supervision of gaming houses, lotteries, billiard tables, tennis courts, &c.). Neale was an inveterate schemer and a promoter of new inventions, for which he was granted several patents; he engaged in foreign trade and became Master of the Mint, 1678–1699. It was one of his patents, that for a pump (A.D. 1675, November 13th, No. 186), that led to the establishment of the waterworks. This patent was for "an Engine or Pumpe serviceable for the Dreyning of Mines and other Uses of that Nature which Forces and Drawes Water in one whole entire Barrell with one and the selfsame Stroake, draweing more Water and raising of it higher with lesse Strength and much more Ease that hitherto any Engine that hath beene invented by any other Person hath done, which said engine hath beene seene and tryed by several Persons knoweing in matters of such nature, and by them approved of as fitter for all sorts of Mines and water-houses in any part of this Kingdome than any of those yett extant." A drawing is attached to the patent grant (see Fig. 38), showing a hollow leather-packed piston (i.e., the "barrell") inside a cylinder or trunk through slots in which project pins to actuate the piston. A muff long enough to command the slots takes the pins and is made to slide up and down on the cylinder. His scheme obviously had no advantage over an ordinary pump, and he must have dropped it quickly in favour of the common leather-packed forcer worked as usual by a horse mill. The illustration is given merely to show from what small beginnings great undertakings can arise.

About the date mentioned above, Neale leased land from the Dean of St. Paul's, at Shadwell, since occupied by the entrance to the Basin there, for the site of his works. In 1679 the works were enlarged and another horse-mill with four horses was added to the plant. In 1681 Neale applied for a

[40] "Cal. State Pap. Dom," 1663–4, pages 585, 599, 625.

Charter and by Letters Patent, June 18, 1681, Charles II granted him "authority[41] to maintain erect or new-build his Water-work and Water-house near the River of Thames . . . in the Parish of St. *Paul, Shadwell*, in the County of Middlesex." Neale divided the concern into thirty-six shares, most of which he sold, thereby netting a considerable sum of money.

In 1691, after the accession of William and Mary, he presented a petition to the Crown for the renewal of his privileges, showing that "with great cost and charges he had erected at Shadwell in Middlesex a water work . . . and that by costly experiments he had found out, as he thinks, a better way to furnish Southwark with water sweet and clear." The outcome was that an Act of Parliament (3 & 4, Wm. and Mary, cap. 37) was passed in that year, incorporating Neale and his partners as a body to be known as the "Governor and Company of the Water-works and Water-houses in Shadwell." Neale was the first governor and Ralph Bucknall, whose name we have already met with in connection with water-works, was one of the twelve Assistants. There was a clause in the Act that the new body should not hinder or obstruct the New River Company, and reserving the latter's rights. There is no evidence that any attempt was made by Neale to supply Southwark with water; indeed, it would have meant laying a main across the bed of the river, a task so far not attempted. Horse mills continued to be employed at Shadwell till 1750.

Although departing from the method of treatment we have so far adopted, it will be convenient to give the rest of the story of the waterworks here. The Governor and Company seem to have been progressive, for in 1750 they replaced the horse mills by an atmospheric engine to cope with the increased demand. Of this engine we have no particulars, nor of another erected shortly afterwards when the first proved inadequate. Maitland, in 1756, has this record :—

"*Shadwell Water-works.*—This office is kept in *Shadwell* and is wrought by two Fire Engines, who supply two Main Pipes of six or seven inch bores with *Thames* water wherewith that Neighbourhood is plentifully furnished."[42]

The area supplied extended from the Tower of London to Limehouse on the one hand, and from the Thames to Whitechapel on the other; about 8000 houses were served. The water-house was situated probably where Nightingale Lane runs to the river at the Hermitage entrance to the London Docks.[43]

The above two engines were replaced in 1778 by one of Watt's construction, built by Boulton and Watt. Indeed, it was the first of his construction for water supply erected in the metropolis. Its cylinder was 27in diameter by 8ft stroke and the pump 10½in diameter by 6ft stroke. This was followed by a duplicate engine in 1784. In 1798 the firm supplied two more engines, one 31⅝in diameter cylinder by 5ft stroke, and the other 6ft stroke, both double-acting.

The waterworks continued to serve the neighbourhood till the demand for dock accommodation in the Port of London led to the construction of the London Docks, for which the area occupied by the water-works was required. In the Act of Parliament (39 and 40, Geo. III, cap. 47) constituting that body there was a clause authorising the dock company to purchase the waterworks for the sum of £50,000 as from September 29, 1807. Until the site was actually required, and till the supply was taken over by the newly formed East London Company, the dock company continued to act as the water authority, as will be recorded later.

(To be continued)

[41] An extract of the Act of Parliament for . . . establishing the East London Water Works, 1808.

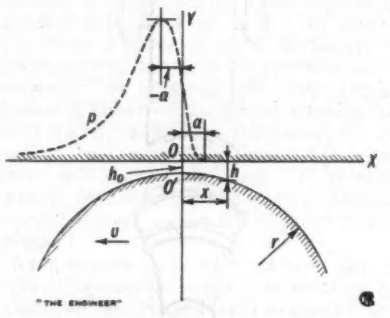
[42] W. Maitland, "History of London," second edition, 1756, page 76.

[43] W. Matthews, "Hydraulia," 1835, page 111.

The Load-Carrying Capacity of the Oil Film between Gear Teeth

By EWEN M'EWEN

THE load-carrying capacity of the oil film between gear teeth is usually stated to be proportional to the square root of their relative radius of curvature (e.g., ref.[1]) and since the Hertzian load-carrying capacity for direct surface contact stress is directly proportional to the relative radius of curvature, the viscosity film index of 0·5 has been invoked as an explanation of the empirical index of 0·8, to which the relative radius of curvature is raised in the methods of Merritt[2, 3] and the British Standards.[4] The basis on which Mr. H. H. Martin[1] obtained this index of 0·5



PRESSURE IN AN OIL FILM

does not appear to have been published, and on further examination it appears erroneous, as we shall show. This, of course, in no way affects the validity of the empirical index of 0·8, which arises since the Hertz criterion is "optimistic when applied to large gears,"[2, 3] but makes it plain that the reasons for this departure from direct proportionality must be sought elsewhere than in the oil film.

Reynold's differential equation for the pressure in an oil film in the absence of side leakages is well known to be (see, for example, ref.[5]) :—

$$d/dx\,(h^3/\mu)\,dp/dx = 6\,v\,dh/dx \quad . \quad . \quad (1)$$

where h is the film thickness at x, p the pressure in the film at x, μ the oil viscosity, and v the relative velocity between the surfaces. This equation is readily integrated to give :—

$$(1/6\mu v)\;dp/dx = 1/h^2 - C/h^3 \quad . \quad . \quad (2)$$

where C is a constant of integration.

The band over which the teeth carry load, whether directly or by the oil film, is narrow compared with the tooth radii of curvature and within this range, by geometry

$$h = h_o + x^2/2r \quad . \quad . \quad . \quad . \quad (3)$$

where h_o= minimum film thickness at $x=0$ on the common normal to the surfaces and r=relative radius of curvature.

One boundary condition is obviously that the pressure above atmospheric, p, will be zero at $x=-\infty$. Further, since the pressure cannot be below atmospheric at the other boundary nor just inside it, we have that at some point $x=+a$, the pressure p is zero and dp/dx is also zero.

Let ϕ be a parameter defined by

$$\cos^2\phi = h_o/h \quad . \quad . \quad . \quad . \quad (4)$$

then

$$x = \sqrt{2rh_o}\,.\,\tan\phi,\; dx = \sqrt{2rh_o}\,.\,\sec^2\phi\,d\phi$$

At $x=+a$, $\phi=\alpha$, $C=h_o\sec^2\alpha$, since $dp/dx=0$. Hence

$$(h_o^2/\sqrt{2rh_o})\;dp/6\,\mu v = (\cos^2\phi - \sec^2\alpha\,\cos^4\phi)\,d\phi \quad . \quad . \quad . \quad . \quad (5)$$

Integrating

$$(h_o^2/\sqrt{2rh_o})\;(p-p_o)/6\mu v = (1-\tfrac{3}{4}\sec^2\alpha)(\phi+\sin\phi\,\cos\phi) - \tfrac{1}{2}\sec^2\alpha\,\sin\phi\,\cos^3\phi \quad . \quad . \quad . \quad . \quad (6)$$

Since

$$p=0 \text{ at } x=-\infty,\; \phi_{-\infty} = -\tfrac{1}{2}\pi$$

$$(h_o^2/\sqrt{2rh_o})\;p/6\mu v = (1-\tfrac{3}{4}\sec^2\alpha)(\tfrac{1}{2}\pi + \phi + \sin\phi\,\cos\phi) - \tfrac{1}{2}\sec^2\alpha\,\sin\phi\,\cos^3\phi \quad . \quad . \quad . \quad . \quad (7)$$

At $x=a$

$$0 = (1-\tfrac{3}{4}\sec^2\alpha)(\tfrac{1}{2}\pi + \alpha + \sin\alpha\,\cos\alpha) - \tfrac{1}{2}\sin\alpha\,\cos\alpha \quad . \quad . \quad . \quad (8)$$

The solution to which is

$$\alpha = 0\cdot4336^\circ \quad . \quad . \quad . \quad (9)$$

The total load-carrying capacity per unit width, P, is given by

$$(h_o^2/\sqrt{2rh_o})\;.\;P/6\,\mu v = \int_{-\infty}^{a}[(1-\tfrac{3}{4}\sec^2\alpha)(\tfrac{1}{2}\pi + \phi + \sin\phi\,\cos\phi) - \tfrac{1}{2}\sec^2\alpha\,\sin\phi\,\cos^3\phi]\,dx \quad . \quad (10)$$

$$(h_o/12\,\mu vr)\;.\;P = \int_{-\frac{1}{2}\pi}^{\alpha}[(1-\tfrac{3}{4}\sec^2\alpha)(\tfrac{1}{2}\pi+\phi + \sin\phi\,\cos\phi) - \tfrac{1}{2}\sec^2\alpha\,\sin\phi\,\cos^3\phi]\sec^2\phi\,.\,d\phi \quad . \quad . \quad . \quad . \quad (11)$$

$$= \Big|(1-\tfrac{3}{4}\sec^2\alpha)(\tfrac{1}{2}\pi+\phi)\tan\phi + \tfrac{1}{8}\sec^2\alpha\,\cos 2\phi\Big|_{-\frac{1}{2}\pi}^{\alpha} \quad . \quad . \quad . \quad (12)$$

$$= (1-\tfrac{3}{4}\sec^2\alpha)(\tfrac{1}{2}\pi+\alpha)\tan\alpha + \tfrac{1}{4} = 0\cdot327 \qquad P = 3\cdot924\;\mu vr/h_o \quad (13)$$

Hence the load-carrying capacity of the oil film between gear teeth is, neglecting end leakage, directly proportional to the relative radius of curvature of the surfaces, not, as has been said, the root of this quantity.

A full discussion of the reasons for the empirical index of 0·8 for the relative radius of curvature in surface load-carrying capacity is beyond the scope of this article. It may be partly due, in Merritt's[2] words, to a "relatively lower standard of accuracy of any type of gear as the dimensions increase"; or it may be due, amongst other things, to the theoretically unsatisfactory nature of the present "speed factors" based on r.p.m. only. The speed effect is twofold, since (*a*) the total life at any stress level is a certain number of repetitions of load so that an increased rate of repetition involves a lower life in hours at a given stress level and (*b*) the stresses due to any given loads at any given standard of accuracy are a function of the pitch line velocity. Thus, assuming a given maximum error in

action, which means a relatively *higher* standard of accuracy in larger gears, at the same cyclic velocity, the larger gear would have a higher pitchline speed so that the use of the same "speed factor" would result in a stress rating which was optimistic for the larger gear if correct for the smaller. It is much more probable that the use of the same speed factor based on r.p.m. alone is the cause of the empirical curvature index of 0·8 than that it should be due to relatively lower accuracy on large gears, which is not in general true; and it has been shown that the oil film load-carrying capacity is directly as the relative radius of curvature.

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[1] Merritt, H. E.: "Worm Gear Performance," "Proc.," I. Mech.E., 129, page 138 (1935).

[2] Merritt, H. E.: "Gear Performance," THE ENGINEER, 166, page 85 (1935).

[3] Merritt, H. E.: "Gears," Pitman, page 228 (1942).

[4] British Standards for Machine Cut Gears 436/1940, 545/1935, 721/1937.

[5] Norton, A. E.: "Lubrication," McGraw-Hill, page 70 (1942).

A French Twelve-Coupled Main Line Locomotive

As an experimental measure to check what could be done by steam traction in the haulage of heavy freight trains over steeply graded lines, the French National Railways has put into service a 2–12–0 locomotive, designed by Monsieur André Chapelon. Officially, this locomotive is considered as a rebuild from a 2–10–0, but the transformation has been so complete as to give what would elsewhere be considered as a new locomotive.

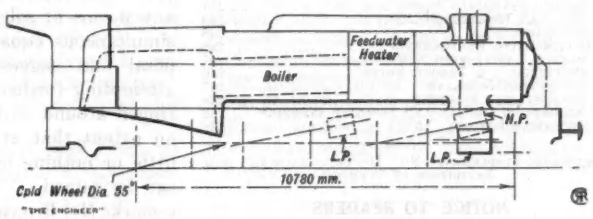
The outstanding feature is not the adoption of six coupled axles, but of six cylinders, a necessary measure if 120 tons of adhesion are to be utilised within the European loading gauge and with compound propulsion. A high-pressure pair of cylinders is set between the frames at the front and drives the second coupled axle. One pair of low-pressure cylinders also is between the frames, farther back, and drives the fourth coupled axle; the second pair of low-pressure cylinders is arranged outside the frames and drives the third coupled axle, as may be seen in the accompanying photograph and diagram.

There are, however, other driving and thermodynamic features of interest. To gain adequate superheat within the low-pressure cylinders without involving too high a figure at the high-pressure valves the principle of re-superheating the high-pressure exhaust has been adopted. Separate smoke tube superheaters, each with its own header in the smokebox, are used for initial superheating and re-superheating. The low-pressure cylinders have been steam jacketed with an annulus of ample dimensions, and probably this is the first time steam jacketing has been applied in conjunction with superheated steam. On the initial trials the results of these measures were that, though the initial degree of superheat at the high-pressure valves did not rise above 380 deg. Cent. and generally was between 300 deg. and 340 deg. Cent., the superheat temperature of the high-pressure exhaust on entering the low-pressure cylinders varied from 270 deg. to 380 deg. Cent., a value that with single superheating would hardly have been possible without an initial superheat of 425 deg. to 475 deg. Cent., with probable lubrication and other difficulties.

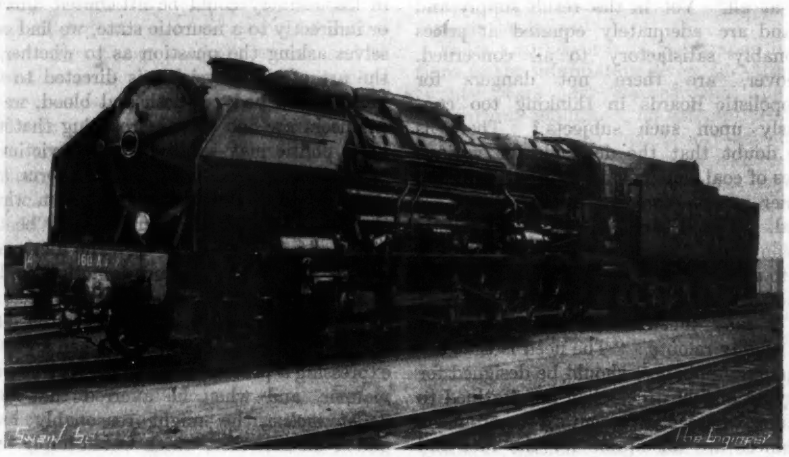
Leading particulars of this locomotive are:—High-pressure cylinders (two), 520mm diameter by 540mm stroke (20·5 in by 21·3in); high-pressure cylinders (two inside), 520mm diameter by 540mm stroke (20·5in by 21·3in); low-pressure cylinders (two outside), 640mm diameter by 650mm stroke (25·2in by 25·6in); coupled wheels, 1·4m (55in) diameter; engine wheel base, 10·78m (35ft 3in); total engine weight, 137·5 tonnes; adhesion weight, 120 tonnes; mean diameter of boiler, 1·83m (72in); length of barrel, 5·7m (18ft 9in); evaporative heating surface, 250·54 square metres (2700 square feet); grate area (trapezoidal grate), 4·4 square metres (47·4 square feet); superheating surface, 72·1 square metres (776 square feet); re-superheating surface, 110·61 square metres (1190 square feet); working pressure, 18 atm. (265 lb per square inch).

Other features on this interesting locomotive include one thermic siphon, Walschaerts valve gear actuating oscillating cam poppet valves, cylinder liners of chrome-faced cast iron, and Kylchap exhaust with double chimney. The boiler barrel is divided into two parts by an intermediate tube plate, but the portion forward of this plate serves as a feed-water heater. The three cylinder groups are arranged with their corresponding cranks at 120 deg., and the introduction of live steam at 10 atm. (147 lb per square inch) pressure to all cylinders at starting promotes an even turning movement that enables the great tractive effort to be taken up without slipping.

The locomotive is now in service in the St. Etienne district, but prior to this work seventeen sets of trials were undertaken with a dynamometer car on the Région du Sud-Est of the S.N.C.F. They comprised three between Villeneuve St. George and Laroche, on the main line, with a 1 in 200 ruling gradient, and six between Laroche and Dijon, with 1 in 125 ruling gradient, both with 1660 tonnes maximum load; two trials between Roanne and St. Etienne over 1 in 83 gradients and with 1050-tonne trailing loads; four trials between Badan and St. Etienne Pont de l'Ane over 1 in 72 gradients and with trailing loads of 855 to 1050 tonnes; and two trials between Lyon (Perrache) and Roanne via Tarare, over 1 in 38/39 gradients and with trailing load up to 578 tonnes. On the Badan to St. Etienne trials a drawbar output of 1612 h.p. was obtained at 30 km.p.h. (18·5 m.p.h.), and the consumptions on these trials were 9·45 litres of water and 3·32 lb of coal per d.b.h.p.-hour. On some of the other tests outputs from 1800 to 2300 d.b.h.p. were obtained on the level at speeds between 20 and 30 km.p.h. (12½ and 18½ m.p.h.); and at a top speed of 60 km.p.h. (37·3 m.p.h.) the drawbar pull was 12 tonnes (26,500 lb) and the drawbar output 2650 h.p. A maximum starting tractive effort of 38 tonnes (83,800 lb) was registered during the course of the trials, and this corresponds to a factor of adhesion of 3·16. Trains of 1660 tonnes of sixty-five wagons were started regularly on 1 in 125 gradients combined with curves, and with starting efforts up to 79,000 lb. On one main line test an average output of 1700 d.b.h.p. at an average of 29·3 m.p.h. was maintained for 2¾ hours on end at consumptions of 8·54 litres of water and 2·72 lb of coal per d.b.h.p.-hour.



ARRANGEMENT OF LOCOMOTIVE



SIX-CYLINDER 2-12-0 LOCOMOTIVE

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1.

PORTABLE FIRE EXTINGUISHERS OF THE WATER TYPE (SODA ACID)

No. 138: 1948. The second revision of B.S. 138, which was originally issued in May, 1922, has just been published. The class of extinguisher to which this standard applies is that in which the pressure required to expel the liquid contents is generated by the chemical action of an acid, in conjunction with a carbonate or bicarbonate solution. The principal object of the revision is to provide for welded construction in addition to the construction already covered in the original document. The standard provides full details of the materials to be used, of the methods of construction, of the tests to be carried out on the finished extinguisher and of the required markings. Price 2s. 6d.

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No. 1170: 1947. A draft of this standard was rushed out during the war at the urgent request of Lloyd's Register of Shipping, and it has now been reviewed in the light of experience and many useful appendices have been added. B.S. 1170: 1947 is, in fact, a great improvement on the wartime draft and should be in the hands of all chief engineers and marine engineering students. Summaries of the various methods of water treatment are published separately for ready reference. The fact that some shipping concerns have turned back from diesel to steam turbine is in part due to the outstanding success of properly controlled boiler water treatment. Price 10s. 6d.

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THE "COAL" PLAN

COAL being now a nationalised industry, there has, of course, to be a "Plan" for its future development. For no public body, to-day, least of all a nationalised body, can be allowed to admit that its operations are in fact ruled from year to year by mere expediency! The Summer School, held by the Coal Board at Oxford last week, mainly for the benefit of the rank and file of the administrative staffs, provided a particularly good opportunity to learn upon what lines the Government, the Board itself and the officials of the Board are thinking in their endeavours to formulate the necessary plan for the future of coal. In his contribution, for instance, Mr. Browne, Chief Mining Engineer (Reconstruction and Planning), reviewed "The First Principles of a Production Plan." Yet, though it is regarded as essential that there should be a plan, it is obvious enough from Mr. Browne's contribution that it is proving very far from easy to draw up a nice tidy ideological one, for what is, after all, not merely the technical operation of winning coal from the mines, but a commercial operation, too, in the selling of the product.

There is, of course, no difficulty about laying down the main essentials of a plan. Mr. Browne summarised them as "the allocation of production between the various coalfields, the determination of the extent and rate of reconstruction work, the allocation of capital expenditure and, where necessary, the redistribution of labour" and "the preparation of a co-ordinated scheme for reconstruction." An ideologist who had formulated such objects of a plan would certainly regard them as sufficient alone to justify a policy of nationalisation. For how else, than by the co-ordination that nationalisation brings could such principles be put into operation? But let us follow Mr. Browne a little further. For as soon as the attempt is made to translate the enunciation of fine broad and very desirable principles into the tedious everyday detail of a practical plan, the task becomes immensely difficult. Listen to Mr. Browne. "There are so many imponderables, conflicting factors and complications that the formulation of a plan might well be dismissed as an insuperable problem. The factors which bear upon the determination of the plan are themselves variable and dependent upon other factors. There is no simple equation to be found to lead to the solution, but a series of highly complex simultaneous equations." This summary of the situation was fully borne out by the rest of Mr. Browne's contribution. Indeed, in reading that contribution we were driven to wonder whether there is, in fact, any means of solving his "highly complex simultaneous equations"! For every proposal and suggestion that he makes in attempting further to elaborate a plan is ringed around with "ifs and ans" to such an extent that at the end the reader has little or nothing left of which a firm grasp can be gained. "The kernel of our task," remarks Mr. Browne in another passage, "is to relate the estimates of the potentialities of the coalfields to the forecasts, however provisional, of distributed demand." It is an unexceptionable statement, a statement which, with but little adaptation of its terms could be applied to any industry or, indeed, to any firm. In industries not nationalised the task is performed without much conscious effort through the individual work of various firms and there is, of course,—a serious defect in Socialistic eyes—no conscious overall plan at all. Yet in the result supply and demand are adequately equated at prices reasonably satisfactory to all concerned. Moreover, are there not dangers for monopolistic Boards in thinking too consciously upon such subjects? There is little doubt that the demands for various grades of coal will not be distributed in the manner most convenient to the Coal Board. The Board, in its monopolistic position, must thus be open to the temptation to exercise some compulsion on the user to use particular fuels. Nor does the danger that it may succumb to that temptation seem wholly remote. "The need is that the consuming appliances should be designed for the types of fuel which they are destined to consume, whereas at present all too often the appliances are unsuitable for the fuel and *vice versa*" says Mr. Browne. Again, in relation to complaints from the electricity industry about the deterioration of fuels, he says "the real ground for that complaint lies in the fact that the quality of fuel has changed without proper negotiations and power stations have been forced to take coal for which their existing steam-raising plants have been unsuited." There is certainly some justification for those statements. But would Mr. Browne, as the mouthpiece of the Board, use quite such language when speaking to buyers in the competitive export market? Would the Board not rather endeavour to raise the quality of its fuels to suit the demands of the buyers, and if the inferior fuel still had to be produced, encourage its more extensive use by quoting a particularly favourable price?

It is trite to remark that the price of fuel (predominantly coal) enters into the cost of producing more or less everything made in this country. But it is necessary to emphasise the point because the consumer of coal is not primarily interested in the Coal Board's plans, but in the consequences of those plans as expressed by the quality of the fuels produced and their prices. That was one of the points to which, as befitted the Chairman of the Industrial Consumers' Council, Sir Ernest Smith directed the attention of the School. It was reiterated by Lord Hyndley. "It is no good thinking that prices can be increased indefinitely. There comes a time when people will simply burn less coal rather than pay out more money." Mr. Alfred Robens, Parliamentary Secretary, Ministry of Fuel and Power, phrased it more forcibly still. "It should be clearly understood that the industry cannot look upon the consumer as a milch cow and merely go on increasing the price of coal to cover the extra costs." That is a remark that might well be taken to heart not merely by the miners, but by workers in many other industries. For improved standards of living can be attained just as effectively through reductions of price as through increases of wages.

INDUSTRIAL NEUROSIS

A CERTAIN analogy exists between the medical profession and that of the engineer, in that the former's aim is to ensure the maintenance of the human machine, while the concern of the latter is the machine which his own genius has evolved. Thus, when it is realised that years ago doctors affirmed that nearly half the illness in the country could be attributed directly or indirectly to a neurotic state, we find ourselves asking the question as to whether, if the art of the physician is directed to the healing of a body of flesh and blood, we as engineers are too slow in realising that the body politic may similarly be the victim of neurosis, and possibly in an acute form, and that half the industrial diseases from which the modern generation suffers may be the result of a form of neurosis. The dictionary defines neurosis as a neurotic action or disorder, one in which the nervous system is vitally affected, and accordingly often difficult to treat. The ancient Latin had a way of expressing a profound truth in a very concise manner, and when he averred that *mens agitat molem*, he might reasonably have added the converse, which would imply that circumstances move the mind. It thus seems a profitable study to instance some of the industrial diseases to which our calling is subject, and to examine the possibility, after diagnosis, of finding a satisfactory cure.

Among the chief diseases we encounter, the one causing the greater threat to production is to be found in the strike, while of almost equal importance is the less spectacular but deadening influence of absenteeism, with all its unhealthy repercussions—

truly an infectious malady. These two are readily apparent, but there are many sicknesses which lead to industrial neurosis, too many even to name, some of which, if allowed to develop, may eventually result in the two maladies instanced. Unsuitable work, ineffective leadership, absence of team spirit, deadly monotony, uncongenial surroundings, a sense of frustration not readily accounted for and probably due to a variety of causes, each of which in itself might be regarded as so trivial as to be unworthy of consideration, and yet together conspiring to produce the disease—all of these need careful watching with a view to finding the necessary serum to inject or the appropriate counter-irritant. Much has been done in the way of welfare work and brightening of factory surroundings, but it has often been undertaken in an unenlightened manner, thus perhaps even leading to a subconscious resentment on the part of the worker. Employers have been heard to boast of all the amenities introduced by them to benefit their workpeople, as if they should be credited with altruistic motives, whereas what they have done in reality tends to increased efficiency in the organisation, leading eventually to increased production. When we come to the question of finding the cure it has to be confessed that there is no royal road to success, although a great deal has been done by those who already realise the seriousness of the complaint and the need for prompt action. Much has been said and written as to the value of psychological tests to determine the fitness of an individual for employment, and admittedly some of the examples evolved are very ingenious; but it is felt that the application is much more limited than its exponents would have us to believe, and while it might rule out the unfit, it might also have a prejudicial effect on those who can never give of their best when they know they are under observation.

Probably much of the industrial neurosis of the present day can be attributed to the small happenings of every-day life rather than to something patently wrong, and to meet this condition something can be done by a more careful selection of supervisory staff. In days when increased production is being urged, managers and foremen alike are inclined to attempt to apply the big stick, regardless of the maxim enunciated by Arnold Bennett that "hustle is not work, but the enemy of work," or, in the language of another, "the boss inspires fear, the leader inspires enthusiasm," for it is in those firms that succeed in inspiring enthusiasm that neurosis is unlikely to flourish. The good leader can foster team spirit, which dispels the evil spirit of frustration, and he also recognises the great importance of interest in one's work. This can largely be effected by taking each and all into his confidence and demonstrating how the contributions of each produce the co-ordinated whole. Change of duties can often be arranged to alleviate the monotony of life, and also to widen the outlook of the individual. But when all is said and done, there will always be those who fail to respond. To attempt to meet their needs, experiments have been made in setting up the equivalent of industrial hospitals, where workers are admitted as "patients," are given regular interviews and are subjected to physical training and occupational exercises. Everything is done to make them self-reliant and forgetful of their worries, and before discharge they are submitted to tests with a view to determining the nature of the work to which they are best suited, and employment found for them, if possible. If after exhaustive tests it is considered that a man is unemployable, a very sheltered occupation is sought for him. Such hospitals are in their infancy and we can but await results. It is often asserted by the doctor that most diseases can be cured if taken in time, and we suggest that the same can be claimed about industrial neurosis. Let each employer first realise that there is such a complaint, then let him examine the cause, and proceed to eradicate the trouble before it has assumed dangerous proportions, and he may well reap a golden harvest.

Obituary

H. W. COUZENS

We have learned with deep regret of the death of Mr. Harold William Couzens, which occurred, after a period of indifferent health at "Tepestede," Chipstead, Surrey, on August 24th. He was particularly well known in electrical engineering circles, having practised in Westminster as a consultant for nearly fifty years.

Harold William Couzens was born at Totnes in 1871, and soon after the completion of his technical education at Finsbury College he was appointed Borough Electrical Engineer of Taunton in 1892. It is of interest to recall that he was the second holder of that office. Couzens remained at Taunton until 1895, and then joined the firm of Kincaid, Waller and Manville, with whom he worked until 1906. In that year, with the late Mr. Morgan Williams, M.I.C.E., he started the firm of Morgan Williams and Couzens, consulting engineers, in Victoria Street, and when Morgan Williams retired in 1912 he took Mr. Douglas A. Brown into partnership. Some years later Mr. Couzens' son, Mr Reginald Couzens, became a partner in the firm, which has continued to practise under the name of Couzens and Brown.

A great deal of Mr. Couzens' work was carried out for electricity supply companies and municipal undertakings, both in this country and abroad. He took a prominent part, for instance, in the formation of the Wessex Electricity Company, and was, in a large measure, responsible for the promotion of the Parliamentary Bills for that undertaking and for the Bedfordshire, Cambridgeshire and Huntingdon Electricity Company. Other work which he did during his long years in consulting practice was concerned with the preparation and supervision of schemes for the engineering services of hospitals, factories, schools and many other public and private buildings.

Mr. Couzens joined the Institution of Electrical Engineers in 1896, and was elected to full membership in 1900. He was also one of the oldest members of the Association of Consulting Engineers.

Literature

Horology. By J. Eric Haswell, F.B.H.I. London: Chapman and Hall, Ltd. 16s.

This book, a reprint of a work originally published in 1928, is a really excellent textbook for all who are interested in the measurement of time, and the construction of clocks and watches; for very clear and well-illustrated explanations are a characteristic feature throughout.

There are, however, some strange limitations to the information given, for, although twenty years have elapsed since the first edition was published, no attempt seems to have been made to include any account of the more modern advances in timekeeping, such as the quartz crystal clock and the synchronous a.c. mains-driven clocks, in this latest reprint. Instead, the book remains substantially the same as it was in 1928, the only changes being the inclusion of a supplement, which corrects and adds to the already existing matter in earlier pages, and the rectification of some small printing errors. This is a great pity, for it is apt to give the very erroneous impression that no really notable advances have been made in the science of horology during recent years. Without any description of the more up-to-date methods of precision time measurement and distribution the book is of necessity incomplete, and that lack of completeness is all the more unfortunate in view of the high standard set by the author in dealing with the older forms of timekeepers.

Beginning with a description of the methods of time determination by astronomical means, passing on to a brief history of timekeeping instruments, and then devoting a group of eight chapters to clocks and nine chapters to watches, the book covers these aspects of horology exceptionally well. The line drawings deserve special mention for their uniform excellence.

Two points which seem to call for criticism in the section on clocks are the rather contemptuous dismissal of modern chiming clocks in a few lines, and the absence of any description of modern tower clocks. The modern quantity-produced chiming clock is by no means always the rubbishy mechanism that Mr. Haswell seems to suggest, and the latest type of tower clock is as much in advance of the types of weight-driven clocks illustrated as the latter were in advance of the old "birdcage-frame" types. The half-tone illustrations seem capable of improvement, though the fault may well lie with the paper on which they are printed. The really outstanding feature of the illustrations is the series of large drawings of escapements, which are excellent.

The last part of the main section of the book is devoted to marine chronometers, and, beginning with a brief historical survey, covers both the construction and use of modern chronometers in a very able fashion. A very complete index follows, and beyond this is the supplement, consisting of eighteen pages of useful matter. It seems strange that no attempt has been made to embody this supplement into the main part of the book at the appropriate places. For instance, the erroneous statements concerning the Wells Cathedral clock have been allowed to remain on pages 22 and 23, although a correction appears on page 273 in the supplement. Also, the supplementary note on page 285 rather contradicts the details of the history of the fusee given on page 82, but the original matter appears in unaltered form.

On the whole, the book is very soundly

written, and its main defects are those of omission. Before it is again reprinted a complete, if brief, account of modern horological developments should be added, and if these are dealt with in the same thorough manner as those already described the book should become one of the best standard textbooks on horology.

The printing and binding of the book are good, particularly when present-day difficulties are taken into account. The type face chosen is an easily readable one, and the binding, in blue cloth, is stout enough to stand up to the frequent handling that a textbook inevitably receives. All too frequently, these important points receive scant attention, but the needs of the student have received attention in this case.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

STANDARDISATION OF WORDS AND ABBREVIATIONS

SIR,—Correspondents to THE ENGINEER have already debated some of the pros and cons of adopting in this country the two abbreviations "psi" and "btu," which are now regularly used in American printing. The issue, however, raises a much larger problem, viz., that of standardising all engineering symbols and abbreviations.

A recent study of the abbreviations used by British technical journals revealed that nearly all periodicals have their own house rules, which very rarely conform with the British Standards Institution's recommendations in B.S. 560 : 1934—Engineering Symbols and Abbreviations.

Most people rely on their newspapers, books and periodicals to guide them in word form and spelling, and as British technical journals as a whole have not adopted a common standard for their engineering abbreviations, it is not surprising that teachers, students and engineers use different forms. Typists, too, appear to have no standard guide to help them.

One repercussion of this is that it requires considerable work on the part of editorial staffs to standardise to their own rules the various abbreviations used by different contributors. It is surely in their own interests for printers, publishers and editors to encourage the use of one common standard, but very few, so far, have adopted the 1945 amendment to B.S. 560 : 1934, which recommends that the full point "shall be omitted in all cases of single-word abbreviations relating to units and quantities" (for example, lb ft cm), "except where doubt may exist whether the letters given represent a complete word or abbreviations." This amendment also recommends that the solidus (/) be used for "per" and that the full point be omitted before a solidus (for example, lb/sq. in.).

It has been noted with considerable interest that THE ENGINEER, in August, 1946, adopted these recommendations. As the previous style had been in use by your journal for ninety years, this was, indeed, a remarkable step, but a glance at the abbreviations used in some of the trade advertisements shows that not many have followed this example.

The present casual use of abbreviations is almost equally matched by the way in which the British use alternative spellings for some words, perhaps the most troublesome of which are those with the suffixes "ise" or "ize" for certain verbs, together with their derivatives "isation" or "ization."

In 1911, "*The Concise Oxford Dictionary*" adopted the suffix "ize" although it recognised that "ise" was at that time the commoner in British (as opposed to American) printing. Nowadays, while "ize" is the standard throughout the U.S.A., in this country we appear to be changing over from one to the other; certainly it would be difficult to decide which of the two forms is now the commoner. Many of the leading publishers, newspapers (including *The Times*) and editors of both technical and non-technical publications, have adopted the suffix "ize," and its use is likely to be further encouraged by the fact that no alternative form is now given in many of the popular dictionaries.

To bring order out of this confusion, do we not need a general agreement for the adoption of a common standard—without alternatives, if possible—for both words and abbreviations?

A. F. SMITH
Commander (E), R.N.

Limpley Stoke, near Bath, August 26th.

LOCOMOTIVE TOLERANCES

SIR,—In your August 13th issue Mr. R. A. Riddles points out that the locomotive Manufacturers' limits and fits for locomotive work are at variance with those issued by the L.M.S. Railway in 1945. Nowhere is this variance regretted more than in the locomotive industry; but Mr. Riddles, I am sure, recognises that the L.M.A. did not adopt this standard practice without giving serious consideration to all available facts and systems, a procedure to which you yourself referred in your editorial in the issue of July 30th.

The L.M.A. sub-committee charged with the work sat regularly from January, 1944, until November, 1945. Throughout that time they were in close touch with all the railway companies in this country, and there was considerable correspondence between the writer and the late Mr. J. Rankin, who at that time was chairman of the L.M.S. committee dealing with that company's limits and fits.

As Mr. Riddles says, due consideration had to be given to practice on overseas railways. Indeed, the practice eventually adopted, of which the combined "hole" and "shaft" basis was one feature, was due not merely to the needs of actual manufacture in a number of works not under unified control, but to the needs of customers at home and abroad in ordering, assembling and fitting spare parts, and to the desire to cover as far as practicable the terms of all existing practices.

The L.M.A. standard practice, therefore, whilst thoroughly practical, is of wider potential application than the otherwise excellent L.M.S. system and B.S.S. No. 164. In practice, though both of those systems might conceivably be applied to British Railways' steam locomotives, they are based partly on the requirements in other branches of engineering, and they do not take account of the widespread industrial application, nor of the important export trade. In that sense they are fragmentary, whereas the L.M.A. practice was drawn up specifically for locomotives and to cover the needs of manufacture for both home and foreign markets—industrial and railway, and steam, electric or diesel locomotives. That is one reason why it would seem beneficial to base any wider locomotive limits and fits practice on the L.M.A. principles.

JOHN ALCOCK

London, August 28th.

LIMITING FACTORS IN DEVELOPMENT

SIR,—Sir Harold Hartley's address to the Associated Scientific and Technical Societies of South Africa is very interesting, but, in my humble view, it would be more convincing if he would explain why, in the "normal times" before the war, no country was able to use its own resources fully nor purchase the surplus available in other countries. In fact, tariffs and other restrictions were raised by all countries to stop goods and materials being imported!

Because of this inability to make use of what was available, both capital and labour restricted output in practically every industry as a means of self-protection. Ideas and practices formed by years of experience change slowly, and hence it is not surprising that output is still being restricted for fear of running out of a job, particularly in those industries where unemployment was greatest.

Does anyone honestly believe that 350 bricks a day represents the limit in output for an eight-hour day, and yet the idea still prevails in large sections of the community that there is only a limited amount of work to be done. Surely the lesson that has still to be learned throughout the industry is that the limitations of production and consumption are physical in terms of manpower, materials and machinery, and are not financial. Hence the factor of vital importance is to ensure the right amount of purchasing power to enable all that people are willing to produce to be consumed. This is where a new outlook is required on all sides.

ANTONY VICKERS

Isleworth, August 27th.

TRUNK PISTON OR CROSSHEAD?

SIR,—The leader in your issue of August 20th on the above subject gives rise to some interesting thoughts.

The power output of an engine is proportional to the brake mean pressure and the piston speed. The piston speed is limited largely by inertia forces. If, therefore, engines now running with piston speeds in the region of 1200ft to 1500ft per minute were to be redesigned to incorporate crossheads, the speed and therefore the output would have to be greatly reduced. Thus, not only would the cost of the engine be increased by the added cost of the crosshead and its guides, but the cost per horsepower would be further increased by the need to use a larger cylinder for the same output. Surely, in general, present practice is the answer to the query you raise? Where piston speeds are necessarily moderate, as in direct-coupled marine engines, crossheads are usual, but where piston speed is not limited by the special features of a marine drive the crosshead would not pay.

There is a tendency at the present time to apply engines of moderate output, say, 1000 h.p., to marine purposes, although they were designed primarily as stationary engines. The installations usually incorporate some form of reduction gear. In these cases the speeds are usually kept moderate on account of the long life and reliability required by marine engines, and in such installations there might possibly be a case for adopting crosshead construction were demand sufficiently great to justify a special design. In the case of high-speed engines the actual tendency seems to be in the opposite direction to that you suggest, since trunk pistons are getting shorter and shorter, with the object of reducing reciprocating weight. Presumably this trend is justified by the economic circumstances, otherwise the demand would force engine builders to move in the direction that you suggest.

W. A. GREEN

Staines, August 24th.

BOOKS RECEIVED

Modern Workshop Technology. By H. Wright Baker. London: Cleaver-Hume Press, Ltd., 42A, South Audley Street, W.1. Price 28s.

The Railways of Britain, Past and Present. By O. S. Nock. London: B. T. Batsford, Ltd., 15, North Audley Street, W.1. Price 15s.

Historic Researches*

No. XXXVII—POSITIVE RAYS AND ISOTOPES

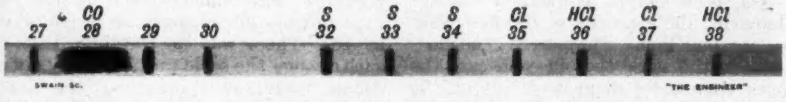
(*Continued from page 217, August 27th*)

ASTON'S first mass spectrograph, built in 1919, had a resolving power about ten times as great as that of Thomson's original instrument operating on the parabolic trace principle. This enhanced power was more than sufficient to settle the neon problem. With neon in his tube Aston obtained a mass spectrum containing two lines which, taking oxygen as 16, corresponded to particles of relative masses 20 and 22 respectively. These figures were whole numbers to the limit of certainty with which they could be determined by means of the instrument. There was no sign of a line at 20·2, the chemist's figure for the atomic weight of neon. Had particles of that mass been present they would have been clearly revealed by a corresponding line on the plate.

It was no longer reasonable to doubt that there were two kinds of neon, apparently identical in their chemical characteristics, but of different atomic weights. Neon, as ordinarily prepared, consisted, it seemed, of an invariable mixture of the two isotopes, the lighter being present to the extent of 90 per cent and the heavier, 10 per cent.

Aston passed on to study other elements which could be obtained in the gaseous state. He soon got further evidence of isotopy. In one experiment he introduced into the tube a mixture of carbon monoxide, gaseous hydrochloric acid and sulphur dioxide. The mass spectrum which he obtained in this case is reproduced herewith. It shows three lines at 32, 33 and 34. for instance, represent four isotopes of chlorine. For various reasons, however, Aston concluded that the 35 and 37 lines were given by two isotopes of chlorine, and that the 36 and 38 lines represented the two kinds of hydrochloric acid molecules to which the two chlorine isotopes would give rise. It will be noted that there is no sign of a line at 35·47, the chemist's figure for the atomic weight of chlorine, and that if particles of that mass had been present the line which they would have produced would have been unmistakable. It was therefore concluded that chlorine as ordinarily prepared consisted of a mixture of two kinds of atoms, of which 77 per cent had a mass of 35, and 23 per cent a mass of 37. Thus the chief reason which had led to the abandonment of Prout's hypothesis—the noteworthy and well-attested departure of the atomic weight of chlorine from being a whole number—was seen to be invalid.

Of the other lines shown in the mass spectrum reproduced, that at 27 can be interpreted as representing aluminium. Atoms of that element would be present in the tube because the anode was an aluminium wire surrounded by an insulated aluminium cylinder. The lines 29 and 30 correspond to two isotopes of silicon, atoms of which would be present in the tube as a result of the electronic bombardment of the protective silica bulb. The most abundant isotope of silicon, it is now known, has a mass number of 28. The line which it gives,



MASS SPECTRUM GIVEN BY MIXTURE OF CO, HCL AND SO_2 (ASTON)

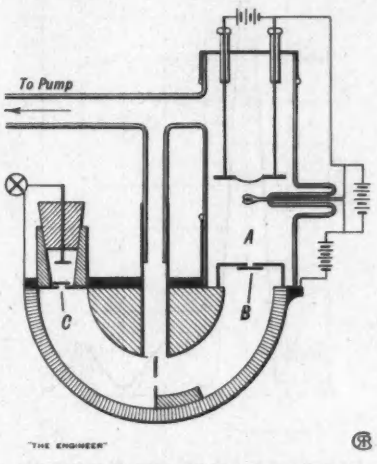
Aston interpreted these lines as being given by three isotopes of sulphur. This interpretation may, at first sight, appear a little daring. Since the chemist's atomic weight of sulphur is 32·06, the implication is that if it has isotopes of the stated mass numbers the lowest must be present to an extent exceeding 94 per cent. Yet the two higher lines are quite clearly marked. Again, the 34 line at least was capable of an alternative interpretation. It might have been given by hydrogen sulphide, H_2S, formed by the union of the 32-isotope with the hydrogen set free by the breaking down of the hydrochloric acid. However, the fact that sulphur has three isotopes of the stated mass numbers has now been fully confirmed.

The four lines 35, 36, 37 and 38 are of great interest. By themselves they might be interpreted in various ways. They might, therefore, coincides with the carbon monoxide line, a fact that may partially account for the unusual width of the CO line in the mass spectrum reproduced.

Aston's earliest experiments were naturally confined to substances occurring normally as gases. To extend his investigations to substances which ordinarily are solids, he dispensed with the protecting silica bulb in his tube and replaced it by a small steel cylinder. Into this cylinder he pressed a paste consisting of powdered graphite mixed with a compound—generally a halide—of the element to be studied. The cylinder was made the anode of the tube and under the intense electronic bombardment, the compound gave rise to positive particles of its constituent elements. For example, if the compound were sodium chloride, positive particles of sodium and chlorine would be present in the tube. The chlorine lines having already been identified, the new lines on the plate would be those due to sodium.

Almost at the same time as Aston was developing his first mass spectrograph, A. J. Dempster, of Chicago, was working on one operating on a different principle. Dempster sought not only to determine the relative masses of the isotopes, but to measure in a direct manner the proportions in which each was present. If an element had only two isotopes of which the relative masses were known, then from the chemist's atomic weight it was a simple matter to calculate the percentage isotopic composition. But if the element comprised three or more isotopes the calculations could not be completed. Even in the case of an element with two isotopes it was desirable to measure their proportional amounts; because if the measured and calculated percentages did not agree, the possibility existed that the chemist's atomic weight was in error or that a third isotope existed which had not yet been discovered.

In Dempster's apparatus positive atoms of the element to be studied were emitted from one of its salts placed on an incandescent platinum plate. Within the chamber A these atoms were accelerated by subjecting them to the action of a suitably directed electro-



DEMPSTER'S MASS SPECTROGRAPH, 1918

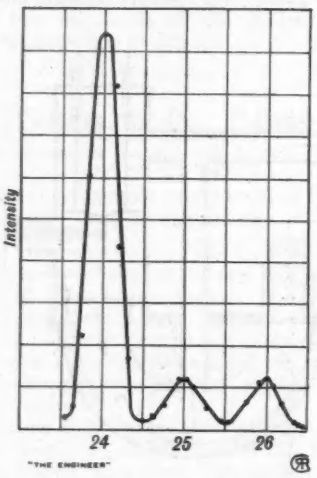
static field of controllable strength. A fine stream of the accelerated atoms emerged from the chamber through a slit B, and passed into a semicircular chamber lying between the poles of a powerful electro-magnet. Under the action of the magnetic field the paths of the atoms were bent into circles, the radii of which were determined by the strength of the magnetic field and the velocity with which the atoms entered it. An exit from the chamber was provided by a second slit at C. The atoms which passed out of the semi-circular chamber through this slit were those which entered it at B with a particular velocity—namely, that required to bend their paths to a radius equal to the radius of the chamber. All the others would be lost by striking the walls of the chamber. The selected atoms leaving through the slit C entered a small chamber, wherein they struck against, and gave up their charge to, an insulated metal disc. An electrometer connected to this disc measured the total charge acquired during a given time.

In use the magnetic field was kept constant while the electrostatic field was adjusted to various strengths. Theoretically, if all the atoms in the chamber A had the same mass, those entering the semi-circular chamber through the slit B ought to have imparted to them some common velocity determined by their mass and the strength of the accelerating electrostatic field. Hence at one particular strength of this field all ought to leave through the slit C. At any other field strength, higher or lower, none should succeed in leaving the semi-circular chamber. If, however, the atoms in the chamber A were a mixture of light and heavy particles, the light particles would acquire a higher velocity than the heavy under the same electrostatic field. Hence at one field strength all the light particles would pass out through the slit C, while at a higher field strength all the heavy particles would

* Nos. I, II and III on "Friction" appeared July 14, 21 and 28, 1944; Nos. IV, V and VI, on "The Mechanical Equivalent of Heat," appeared September 29, October 6 and 13, 1944; Nos. VII, VIII and IX, on "Electro-Dynamics," appeared March 9, 16 and 23, 1945; Nos. X, XI and XII, on "The Ether Drift Experiments," appeared August 3, 10 and 17, 1945; Nos. XIII and XIV, on "Specific, Latent and Atomic Heats," appeared December 7 and 14, 1945; Nos. XV, XVI, XVII and XVIII, on "Chemical Elements and Atoms," appeared August 2, 9, 16 and 23, 1946; Nos. XIX and XX, on "The Classification of the Elements," appeared September 27 and October 4, 1946; Nos. XXI, XXII, XXIII and XXIV, on "Molecular Physics," appeared March 28, April 4, 11 and 18, 1947; Nos. XXV, XXVI, XXVII and XXVIII, on "Conduction of Electricity Through Liquids," appeared October 24 and 31, November 7 and 14, 1947; Nos. XXIX, XXX, XXXI and XXXII, on "Conduction of Electricity Through Gases," appeared March 12, 19, 26, April 2, 1948; No. XXXIII on "X-Rays," appeared June 11, 1948.

emerge. A simple formula involving only the strengths of the magnetic and electrostatic fields and the radius of the semi-circular chamber enabled the specific charge E/M—or its reciprocal, the mass per unit charge—of the particles which passed out through the slit C to be calculated. The charge communicated in a given time to the measuring disc ought to be proportional to the number of the light or heavy particles striking it.

The accompanying curve shows the results obtained by Dempster when a salt of magnesium was placed on the incandescent



DEMPSTER'S CURVE FOR MAGNESIUM

platinum plate. It represents the intensity of the electrical charge given during a standard time to the measuring disc at different values of the electrostatic field strength. The curve is continuous with three well-defined maxima. By means of the formula referred to, Dempster calculated that these maxima corresponded to particles having relative masses of 24, 25 and 26 respectively. The height of the curve at the maximum points indicated that these three kinds of particle were present in the proportion 7 : 1 : 1 approximately. That being so, the average mass of the particles emerging through the slit C at the three maximum settings was 24·33. The chemists' value of the atomic weight of magnesium was 24·32. Dempster therefore concluded that magnesium had three isotopes of the stated relative masses and that they were present in the stated relative proportions.

The fact that the curve is continuous and is not confined to three isolated ordinates at 24, 25 and 26 implies that at *all* values of the electrostatic field strength *some* particles were emerging through the slit C. This departure from the theoretical "all-or-none" result was to be expected from certain practical considerations, such as the effect of collisions on the velocity of the particles and the fact that the slits B and C had perceptible widths.

One might suppose that Thomson, Aston and Dempster between them had definitely established the truth of the isotopic theory and that, beyond a search for the isotopes of certain elements which so far had not been revealed, little remained for them or others to discover. The truth was very much otherwise. The work of these three investigators was merely the spark which set alight the train of momentous developments in physical science which to-day envelop us.

Two considerations had to be faced. In the first place, the theory of isotopy had to be aligned with the firmly held faith in the constancy of the chemist's atomic weights of the elements. If these weights really were constant then it was necessary to believe that in any element consisting of two or more isotopes the proportional composition of the mixture remained unaltered throughout all time and irrespective of the source from which the element was derived. Superficially such constancy seemed improbable. Yet prolonged studies aimed at the detection of minute variations in the atomic weights of the elements had failed, and continued to fail, to reveal any such variation. In particular the atomic weight of chlorine obtained from widely different sources had been found by chemists to be constant within the limits of experimental error. The same absence of variation was established when the atomic weight of iron derived from meteorites was compared with that of iron of terrestrial origin. What factors determine the relative abundance of the isotopes of any one element and preserve the constancy of their relative amounts remain obscure.

The second consideration which had to be faced seemed initially, no doubt, to many to be trifling. It was, or appeared to be, all a question of a discrepancy in the third place of decimals in the atomic weight of hydrogen. Yet it was to prove to be of vast significance and the source of momentous developments.

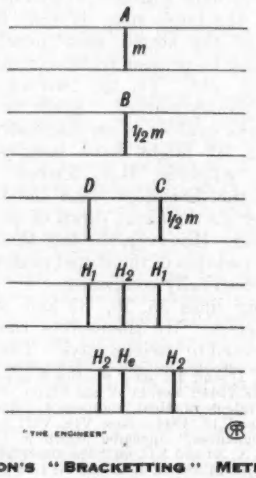
According to Prout's hypothesis, as revived and modified by the discovery of isotopes, all the elements consisted of particles built up of a whole-number aggregate of hydrogen atoms. The elements, it appeared, could be divided into two classes, those which had atomic weights which were exactly whole numbers, or very nearly so, and those which had atomic weights which quite decidedly were not whole numbers. In the mass spectrograph, in its then state of development, the elements of the first class gave only one line. They were "single" elements in the sense that in each case the particles composing them were all of the same kind. Examples of such "single" elements were hydrogen, helium, carbon, nitrogen, oxygen, fluorine and aluminium. All the elements of the second class, so far studied, gave two or more lines in the mass spectrograph. They were "multiple" elements in the sense that each consisted of a mixture of two or more kinds of particles. In every case these different kinds of particles or "isotopes" had been found to have relative masses which were whole numbers to the limits of observation. The lack of integrality in the atomic weights of elements of the second class was thus explained by the fact that each such weight was merely the average value of the whole-number weights of the isotopes.

These facts summarised the evidence in favour of the revived belief in Prout's hypothesis. But there was one other fact which appeared to be against it. The atomic weights of the elements of the first class, and the isotopic weights of those of the second class were whole numbers with respect not to hydrogen, but to oxygen, taken as 16·000. One of the best attested figures of chemistry was the atomic weight of hydrogen. It was certainly not exactly unity. To a high degree of refinement it was believed to be about 1·0077 relatively to oxygen as 16·000. The atoms and isotopes, while they might have masses which were whole numbers on the oxygen scale, could therefore not have integral masses relatively to the mass of the hydrogen atom. How could this fact be reconciled with the hypothesis that the hydrogen atom was the unit from which the atoms of all the other elements were built up? On the hydrogen scale (H=1·000) the atomic weight of oxygen should be 15·873. Hence, if Prout's hypothesis were correct the oxygen atom showed a deficiency of about one-eighth of a hydrogen atom, provided that in the building-up process the doctrine of the conservation of matter were fulfilled.

There were a number of possible explanations to account for the discrepancy, most of them startling and even fantastic. The most obvious one was that the chemist's value for the atomic weight of hydrogen was wrong and that it was really unity, relatively to oxygen. Another was that hydrogen, although it had failed to reveal itself as such, was a "multiple" element. Its atomic weight could be accounted for if it were supposed to consist of two isotopes of relative masses 1 and 2, the heavier being present to the extent of 77 parts in 10,000. This possibility, however, was not very helpful. As an explanation of the immediate difficulty it involved the supposition that the lighter isotope alone took part in the building up of the atoms of the other elements.

Aston addressed himself to the task of confirming or amending, by means of his mass spectrograph, the figure accepted by chemists for the atomic weight of hydrogen. It was useless to attempt to settle a question of this refinement by trying to detect in a direct manner the extent to which the hydrogen line departed from exact coincidence with the position on the mass spectrum scale corresponding to unity. The departure, if any, would be less than 1 per cent and would be too small to observe, let alone measure. In addition, the position of the line corresponding to unity could not be fixed with precision. It had to be inferred by a doubtful process of extrapolation from reference lines much higher up the scale, such as those for nitrogen at 14 and oxygen at 16. There was no certainty that over such a range the scale was uniformly divided. Aston therefore approached the subject in an indirect manner by a procedure which he called "bracketting."

Let A be the position on an Aston mass spectrum of the line corresponding to particles of mass m when the electrostatic and mag-



ASTON'S "BRACKETTING" METHOD

netic fields have particular field strengths—say, E and H respectively. Let now the electrostatic field strength be doubled while the magnetic field strength remains as before. It is not difficult to understand that the effect will be, as shown at B, to bring the line given by particles of mass $\frac{1}{2}m$—if any such are in the tube—into coincidence with the line previously given by the particles of mass m. If

the electrostatic field strength is slightly more than doubled, to some value, say, $2E+x$, the particles of mass $\frac{1}{2}m$ will give a line slightly to one side of the A position and if the field strength is a little less than doubled, to $2E-x$, the $\frac{1}{2}m$ particles will give a line a little displaced to the opposite side of the A position. If the excess x in the one case is exactly equal to the deficiency x in the other—and this in practice can be achieved very accurately—the two $\frac{1}{2}m$ lines CD will bracket the A position symmetrically.

Aston's result when he applied this procedure to hydrogen is represented in the fourth diagram. The central line H_2 is that given by hydrogen molecules. It is bracketed symmetrically by two lines H_1 given by hydrogen atoms, a fact which provides physical proof that the hydrogen atom has exactly half the mass of the hydrogen molecule.

The atomic weight of helium is 4·00 to a high degree of accuracy. When Aston introduced helium and hydrogen into his tube he obtained the result indicated in the fifth diagram. The middle line was given by the helium atoms. When the electrostatic field strength was slightly more, and then slightly less, than doubled, two hydrogen molecule lines appeared. They bracketed the helium line *unsymmetrically*. The inference was that the hydrogen molecule had a mass which was *not* exactly half the mass of the helium atom. The method permitted a close numerical evaluation of the relative masses. It was found that if the atomic weight of helium were taken at 4·00 the atomic weight of hydrogen came out at 1·008. The accepted chemical value was thus confirmed.

Aston published this result in 1920. It did not come altogether as an unpleasant surprise to physicists. Rather did they welcome it as evidence in favour of their growing belief in the soundness of Einstein's theory of relativity. It left them free to believe in the equivalence of mass and energy, which was one of the fundamental deductions from that theory. If they accepted the possibility that mass could disappear as mass and reappear as energy, rigid adherence to the classical doctrine of the conservation of matter could no longer be justified. Freed from the trammels of that doctrine, they were at liberty to suppose that when atoms of hydrogen coalesced to form the atoms of other elements no exact balance of mass was necessarily to be expected. When four atoms of hydrogen, each of relative mass 1·008 combined, they produced, it could be argued, an atom of helium which had a relative mass not of 4·032, but of 4·00. There was a loss of mass of 0·032. That loss, however, was no longer mysterious. By Einstein's principle it would be released and made manifest as energy.

The rate of exchange of mass into energy was prescribed by the theory of relativity. It involved the square of the velocity of light and implied that one gramme of matter was equivalent to 9×10^{20} ergs (or sixty-six million million foot-pounds). The magnitude of this figure was an indication of the importance to be attached to the third place of decimals in the atomic weight of hydrogen. It meant that if one gramme of hydrogen could be completely transmuted into helium the mass which would disappear would have an energy value equivalent to the heat energy released by the combustion of about 30 tons of coal.

One consideration of cosmic significance was at once apparent. Physicists and astronomers had for many long years been at a loss satisfactorily to assign the source of the continuous output of energy from the sun and other stars. It now appeared reasonably probable that the energy output was derived from the loss of mass accompanying the transmutation of hydrogen into helium, followed, possibly, by the transmutation of helium into elements of higher atomic weight. The thoughts of physicists at once rushed out to the possibility that if such transmutation were actually taking place in the sun, it might one day be discovered how to effect it in the laboratory and ultimately in the power-house.

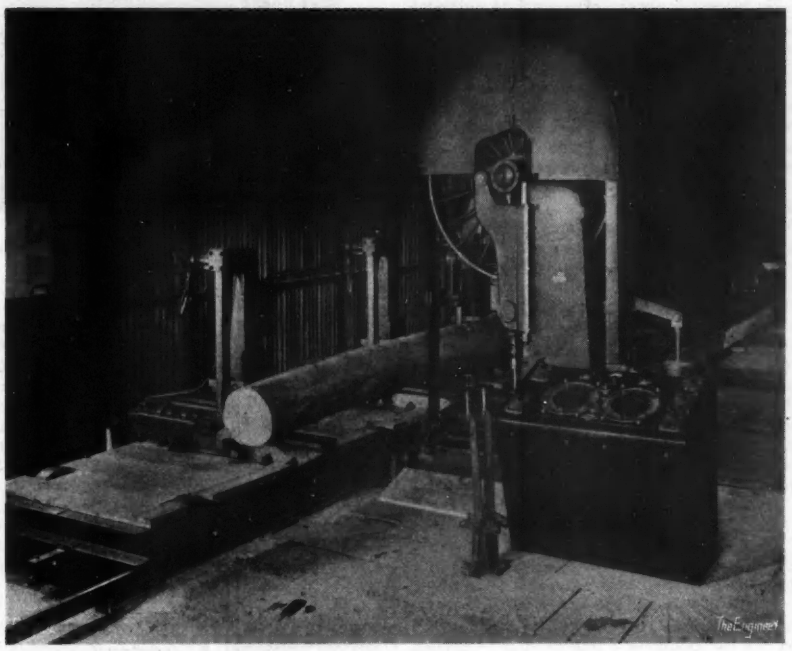
A second consideration was also apparent. Transmutation of the elements in the reverse direction—the breaking down of helium atoms into hydrogen atoms—would involve the expenditure of a correspondingly large amount of energy. No wonder the old alchemists had failed in their favourite endeavour. But was the task beyond the power of modern physical resources? The answer to that question had already been foreshadowed by Rutherford. In 1919 he had succeeded in changing a few atoms of helium plus nitrogen into a few atoms of oxygen plus hydrogen.

At this point in our story we reach the birth of nuclear physics—the offspring, on the one part, of those who had been studying electrons, positive rays and isotopes and, on the other, of those who had been studying radio-activity. Science cannot, however, be divided into neat chapters. One branch may give rise to another, but the parent branch may continue to grow and in time its growth may greatly influence the development of the branch to which it has given birth. So it was to prove in the present case. Knowledge concerning positive rays and isotopes was not complete in 1920. It continued to progress independently of nuclear physics, as will be shown in the next article, and in time fresh discoveries were made which contributed powerfully to the growth of the newer branch.

(To be continued)

A Vertical Log Band Mill

MANY interesting features of design and control have been incorporated in a vertical log band mill recently built by Easton and Johnson, Ltd., of Taunton, Somerset. This mill, which is now in successful operation, is shown in the drawings and photographs we reproduce. It is electrically driven throughout and all its movements are controlled by a single operator standing at a desk so positioned as to give a clear view of the entire working area.



BAND MILL AND CONTROL DESK

The machine is designed to handle logs up to 20ft long and 46in diameter, and with the saw guide removed 1in planks up to 60in deep can be cut.

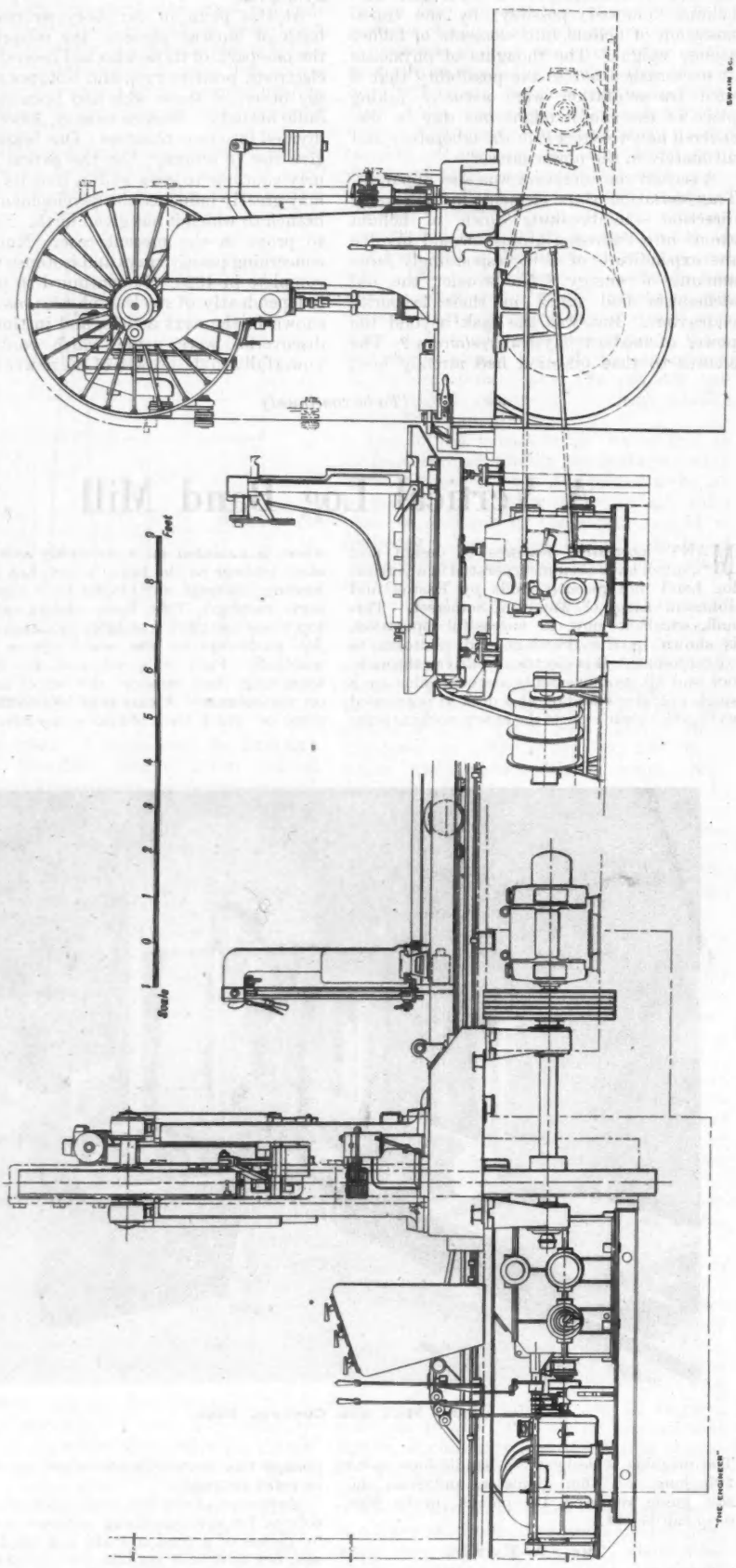
THE SAW UNIT

The saw unit has two 60in diameter driving wheels, each of which is carefully balanced. The bottom wheel of close-grained cast iron is mounted on a forged steel spindle running in two large self-aligning roller bearings enclosed in dustproof housings. The top saw driving wheel is mounted on a revolving axle in the same manner as the lower wheel, but its axle bearing housings are hinged to a supporting horn casting. This horn casting with the top wheel assembly is slidably mounted on wide flat guideways on the main column of the machine. Push rods actuated by the saw tensioning shaft support the wheel assembly on the column. A cast iron box-section bedplate on which the column is mounted incorporates two work take-off rollers which rotate on roller bearings.

Movement of the top wheel assembly on the column for saw tensioning purposes is effected by means of a torsion shaft and weight lever, and saw tension is maintained constant by the adjustment of weights on the lever mechanism. The torsion shaft is carried on knife-edges, that nearest the gullet side having means of fine adjustment for correcting the amount of tilt to the top wheel whilst the machine is running.

ARRANGEMENT OF LOG BAND MILL

EASTON AND JOHNSON, LTD., TAUNTON, MAKERS



For saw tensioning the position of the top wheel is adjusted through a central screw jack of large dimensions which raises and lowers the horn casting on which the bearings are set. The elevating screw is rotated through a machine-cut worm gear, which is self-locking and is totally enclosed. The lifting screw gearing is driven by a high-torque reversing squirrel-cage motor controlled by automatic up and down limit switches. An extra limit switch operated by the saw tension weight loading lever is arranged to cut the motor out when the saw is correctly tensioned. The control of this motor incorporates a mechanical and electrical interlock to prevent the motor being started when the saw wheels are in motion.

A saw steady slide is supported on a steel bracket bolted to the main column. This bracket also carries a motor which is used to raise and lower the slide through a square-threaded screw. The adjusting screw is rotated by machine-cut bevel gears and is driven by a reversing, high-torque squirrel-cage electric motor. A combined slipping clutch in the drive provides a means of releasing the motor drive if the saw steady is lowered too far and rests on the log or any other obstruction. Two limit switches are incorporated into the motor control circuit at the top and bottom positions of travel to provide automatic stopping without calling for attention from the operator. The top limit switch is also controlled by the position of the top wheel, which naturally varies for different lengths of screws.

Special attention has been given to the design of mechanism for wiping the top and bottom wheel rims and for the automatic wiping and lubrication of the saw blade. The top saw wheel is provided with a large paraffin wiper box with adjustable spring-loaded felt pad wipers, and a similar arrangement for the rim of the bottom wheel incorporates means for stopping the supply through double drip pipes to prevent wastage of paraffin when the machine is shut down.

A mild steel guard set over the top saw wheel overlaps the front and back of the wheel and is rigidly supported from the main column, as is also the fixed saw steady bracket. A hinged front plate on the guard, which can be swung clear when taking off the saw, is provided with a central hinge to avoid excessive overhang when in the open position.

The bottom saw wheel shaft is driven through vee ropes by a 50 h.p. slip-ring motor running at a full-load speed of 1460 r.p.m. A fully automatic contactor starter for the motor is built into the main panel and controlled by a "stop" and "start" lever on the operator's desk.

Rapid stopping of the bottom wheel to change saws is carried out electrically through the main motor by automatic d.c. injection breaking, which is designed to bring the saw to rest in thirty to forty seconds.

It will be appreciated that the designers have paid particular attention, when laying out both the main drive and the saw tensioning gear, to facilitate the rapid changing of saws.

The Log Carriage

Power for traversing the log carriage is transmitted through a machine-cut rack and pinion, from a driving unit situated in a pit at the operative end of the log carriage track. This unit is to be seen in one of the photographs reproduced.

The two main side members of the log carriage chassis each consist of twin mild steel channels, machined on their inner and top faces. Each pair of channels is bolted together to form a rigid box-section beam enclosing five axleboxes spaced at intervals along its length. To form the chassis each side beam is cross braced with 4in diameter steel tubes with machined flanges which are bolted right through the double side channels and axleboxes with spigot attachments. Additional cross braces are fitted at each end of the carriage and all cross members are provided on their under sides with slide plates and keep bars which locate the main driving rack. The axleboxes on each side of the carriage are fitted with phosphor-bronze bushes, bored and honed to

take the ground steel axles of the rail wheels. On its side nearer the saw the carriage is fitted with five flat wheels, and on the side remote from the saw with five grooved wheels.

The carriage runs on machined steel flat-bottom rails at 4ft gauge. These rails are supported by steel sleepers designed to permit ready adjustment for sideways alignment and easy removal of the rails for re-machining or packing purposes.

The carriage chassis has an automatic sideways movement away from the saw during the reverse movement, to withdraw the log from contact with the bandsaw. This movement is imparted by bellcrank levers, mounted on each cross member between the axles. These levers are moved a preset amount by the main rack at the outset of the return stroke, and the side thrust they impart is transmitted through two-way ball thrust radial bearings mounted on an extension of each rail wheel axle. These thrust assemblies are arranged centrally in the cross member tubes and are totally enclosed.

Cross-channel braces at each end of the chassis support the main rack extension which provides the required overrun to clear the saw at each end of the loading and take-off positions. The distance between the outermost work-holding headstocks is 20ft and the total length of the chassis frame is 26ft 4in.

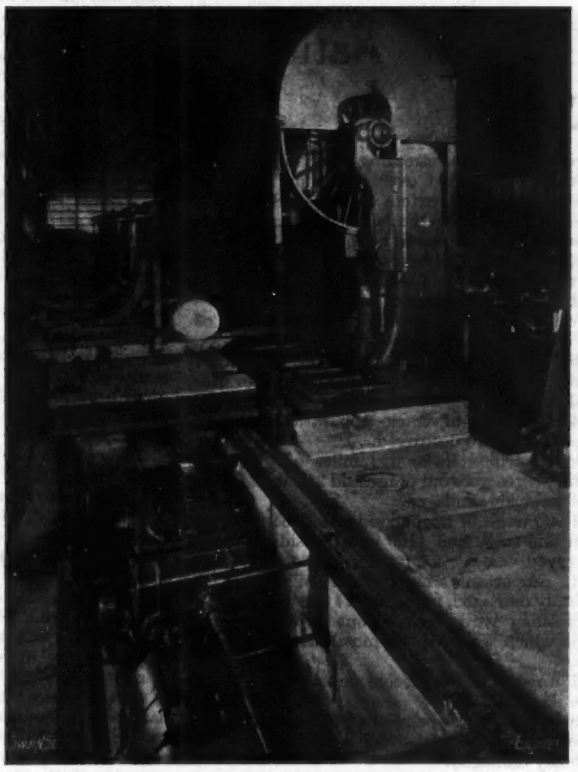
Carriage Drive

The carriage is driven by a 10–15 h.p. totally enclosed, crane-type, pipe-ventilated, a.c. variable-speed commutator motor giving a speed range of 5 to 1. In this motor, which is non-reversing, the speed is controlled by movement of the brush gear. The motor, together with the totally enclosed speed-reduction gearbox which it drives, can be clearly seen in one of our illustrations.

During the cutting stroke of the mill, drive to the rack pinion of the carriage is taken through spur gears, and, during the reverse stroke, through a triplex chain. Drive in both directions is transmitted through a large double-acting, multi-plate clutch, designed to allow for inching and slipping, enclosed within the gearbox. Both the clutch and second motion shafts in the drive unit are mounted on large ball bearings and the idle driving pinions are mounted on roller bearings on the clutch sleeves. Oil pump lubrication is provided for the clutch plates and all gears and also the rack pinion shaft bearings.

The feed and reverse clutch is controlled by a hand lever adjacent to the control desk. To obtain variation in speed for carriage feed the position of the brushes on the variable-speed motor are controlled by a second hand lever. When the machine is working on the slower cutting speeds the carriage driving motor is automatically accelerated to full speed for quick return of the carriage when the reverse clutch is engaged. At the end of the return movement the pre-set motor speed for the working stroke is automatically resumed. The arrangement is such that the increase of speed takes place on the reverse stroke after the clutch has been engaged, and the transmission gears are protected from shock when the carriage is heavily loaded.

A particularly simple yet effective mechanism has been developed for increasing the speed of the return stroke. This mechanism is operated by the oil pressure in the transmission gearbox lubricating line. This oil line communicates with a small hydraulic cylinder, the piston of which is connected by a link to a shaft controlling the rotating brush gear of the motor. When the reverse clutch of the carriage drive is engaged a solenoid is automatically energised to close a valve at the end of the line freely supplying lubricant to the gearbox. When this valve is closed pressure in the line builds up and raises the piston in the hydraulic cylinder situated lower down the line. Movement of the piston rotates the control shaft



Carriage Driving Unit

and thus the brush gear of the motor to introduce a higher speed. At the end of the carriage return stroke the solenoid is de-energised and the opening of the valve it controls releases the oil pressure in the line and thus below the piston of the hydraulic cylinder, which is returned to its normal position by a weight. In its return movement the piston rotates the control shaft in the opposite direction to restore the brush gear to the normal motor carriage feed speed position. This speed-accelerating gear can be clearly seen on the side of the carriage driving unit shown in the photograph.

Carriage Headstocks

Five gripping dog headstock slides mounted on the carriage to hold the logs are of heavily ribbed cast iron construction and have a maximum movement of 40in away from the saw. These headstocks are moved across the carriage by machine-cut racks and pinions driven by a shaft running the full length of the carriage. This shaft is designed to maintain the precise alignment and give simultaneous movement to all the slides. Top and bottom gripping dogs on the headstocks have hardened steel points and are fixed to the slide bars with cast steel clamps. The dogs are tightened on logs by means of levers through Acme buttress thread screws, final grip being effected with a hand ratchet lever which actuates a pinion engaging machine-cut teeth in the vertical slide bars.

Power is used to drive the shaft which moves the headstocks towards and away from the saw, and the mechanism incorporates means of pre-setting and repeating feeds. The power feed is driven by a 1¼ h.p. high-torque reversing motor geared to the headstock torsion shaft through a simple worm and planetary reduction gear in which the planet gear ring is left free to revolve. Instantaneous stopping of the feed movement is controlled by a spring-loaded pawl, actuated by a solenoid, which allows the pawl to disengage the planet ring at the instant the pre-set travel of the dogs has been reached. This movement disconnects the motor drive and cuts out any overrun effect of driving motor inertia resulting from different load conditions. This feed gear is provided with an interlock and cannot be operated while the carriage is moving on the cutting stroke, and it can only be started when the carriage is in the side stepped position during reversing or when stationary.

Electrical Control

The design of this machine has been based on electrical drive and electrical control throughout, and is divided into five main sections for control purposes at the main control desk of the machine. One operator controls the entire running of the machine without leaving his position—the only manual assistance required is for loading and unloading the logs and cut timber.

Full automatic contactor gear is incorporated in each circuit with contactor-operated interlocks. As the starting and stopping of each motor circuit is controlled in the correct stepped sequence no skill is required on the part of the operator to start the motors at the required rate to avoid excessive starting currents.

The five sections of the electrical control are divided as follows:—(*a*) Main motor starting, (*b*) main motor stopping, (*c*) carriage motor drive, (*d*) automatic feed with pre-selecting and repeating feeds, (*e*) rapid traverse motor for saw steady, (*f*) electric motor power drive for saw tension with automatic cut-out at the correct tension and interlock with the main motor.

All the circuits are arranged on a main contactor panel. The five control sections are each provided with automatic limit switches which provide positive stopping of the motor concerned and prevent overrun.

On the control desk are two graduated dials reading 0in to 40in, which are illuminated from underneath to provide clear reading for the operator. The left-hand dial is graduated in eighths of an inch and is fitted with a movable pointer which is placed by the operator at the desired thickness to be cut. When the thickness of plank has been selected the operator moves the "auto feed" control handle to the "feed in" position, and the headstocks start moving towards the saw. As the feed starts a red "auto feed running" lamp on the control desk lights up and when the pre-selected position of the log in respect to the saw has been reached the drive automatically cuts out. The running lamp is automatically switched out at this point and the feed mechanism returns to the zero position ready for feeding the next cut. The feed sequence is thereafter automatically repeated to the same thickness until the pointer is moved to a fresh position.

The right-hand recording dial pointer automatically follows the movement of the headstocks and shows the operator the position of the headstock faces, and thus the log in respect to the saw. When the feed-control handle is moved to the "reverse out" position the headstocks withdraw from the saw to any point required as registered on the recording dial.

A simple pre-setting thickness control also incorporated in the feed-selecting dial mechanism provides micro adjustment for the thickness of cut if there should be any variation in the setting of the saw teeth on the various saw blades being used.

When, to start the main saw-driving motor, the handle is put to the "start" position, the main contactor is energised and the main current to the stator and rotor circuits of the motor

is switched on. The rotor current is passed through two banks of resistances, each being cut out in the correct sequence automatically as the motor speed increases finally leaving the motor switched straight to the line and running at full speed. The resistances are rated and the sequences timed to limit the amperage to full-load current at each step.

When, to stop the main motor, the lever is put to the "stop" position it opens the line contacts and switches on the d.c. injection current into the stator circuit. This brings the motor to rest and automatically switches the circuit out when the motor has stopped. No mechanical braking or manual operation of any sort is required by the operator to stop the machine.

The carriage motor is non-reversing and is started by putting the lever to the "start" position, but as there is an interlock in the brush gear of the motor the speed-control hand lever must be put to the "slow" position before starting. This arrangement is necessary to avoid full-load current being switched on with the motor at rest. As soon as the motor has started the hand speed lever can be moved to give any desired speed to the carriage.

Controls for the rapid traverse motors of the saw steady and saw tensioning gear are simple reversing direct-starting contactor circuits and are both arranged for "push to run" controls in each direction of travel. The operator holds the control lever in the required direction of travel, and on the lever being released the motor stops.

Reconstruction of the French National Railways*

IN 1939 the lines of the French National Railways covered approximately 26,500 miles, of which approximately 2100 miles were electrified. These lines, built with one, two, three or four tracks, had a total single-track development of 40,400 miles, not including approximately 15,000 miles of service lines.

The railway system's permanent way and works were in good condition and were being modernised at a fairly rapid rate—electrification, automatic block signalling and the installation of modern marshalling yard equipment had been developed to a considerable extent. The excellent condition of the permanent way made high speeds possible. The general speed limit of 75 m.p.h. had been increased to 81 m.p.h., and even 87 m.p.h. for certain trains on certain lines.

Work was undertaken on a large scale and in many places on the elimination of the busiest level crossings and dangerous rail crossings, as well as on the modernisation of buildings and passenger stations. Special efforts in this direction were made in the case of the harbour stations in Havre, Cherbourg and Boulogne and Calais Maritime.

The rolling stock was superabundant in relation to the economic level of 1938, but heterogeneous and, in many cases, old. There were no less than 220 different types of engines.

The economic depression during the years from 1935 to 1939 had appreciably slowed down the renewal rate, and during this period only the following orders for new stock were placed :—97 steam locomotives, where normal renewal required 1400 ; 856 passenger coaches, against 2500 required ; 8750 goods vehicles, against actual requirements of 40,000.

The stock of vehicles on the S.N.C.F. was made up as follows :—

	Total stock	Number normally available for service
Steam locomotives	17,058	12,600
Electric locomotives...	772	600
Electric train motor units ...	443	360
Passenger coaches and vans ...	37,763	28,000
Goods trucks	478,000	400,000

The total number of the staff employed was 515,000.

Before the war the daily mileage covered by passenger trains travelling at a service speed of over 60 m.p.h. was approximately 15,535.

After having reached its maximum level in 1930 with 790 million passengers and 253 million tons of freight, traffic decreased regularly until 1938, during which year the results were as follows :—Freight carried, 151½ million tons ; passengers carried, 540 million.

Damage and Losses During the War

Way, works and rolling stock sustained exceptionally extensive damage due to the successive effects of military operations, particularly bombing, the action of the underground army and, finally, the systematic destruction carried out by the retreating German armies.

Damage sustained over the whole territory greatly exceeded in extent that of 1918. At the time of the liberation the railway system was left in such a condition as to be unable to meet the most pressing requirements of the conduct of the war and the life of the country. The following bare figures sum up the tragic reckoning :—

Traffic was only possible on 11,125 miles of line out of the system's total of 26,500 miles.

2603 bridges, viaducts, &c., and 70 tunnels were destroyed or severely damaged and the total length of the breaches exceeded 62 miles.

14,000 items of track apparatus and 688 signalboxes were destroyed.

On electrified lines, 620 miles of overhead contact wires were out of use and 26 sub-stations were seriously damaged.

41,000 miles of telephone lines, 1864 miles of main line track and 1100 miles of sidings were destroyed.

115 important stations out of 322 were seriously damaged, including 24 out of 40 large marshalling yards and 62 out of 64 transhipment yards which were for the most part unserviceable.

71 important locomotive depots out of 130 were demolished.

19 large repair workshops out of 31 and 15 large store depots out of 29 were destroyed or seriously damaged.

1074 acres of buildings required reconstruction.

The rolling stock, in addition to the war damage it sustained, had been largely drawn upon by the occupying forces, and all that was left available for use in France was 3000 steam locomotives, 500 electric locomotives, 300 electric train motor units, 6200 passenger vehicles and 172,000 goods trucks.

Stores had shrunk to an unprecedented low level ; only 22,000 metric tons of rails, 2,200,000 sleepers and 540 items of track apparatus remained in stock, compared with a pre-war annual consumption of 200,000 metric tons of rails, 4,500,000 sleepers and 3300 items of track apparatus.

The total volume of reconstruction work to be undertaken was estimated at the time at about 200,000 million francs.

The Paris region was almost completely cut off from the rest of the country. All the bridges over the Loire, from Nantes to Nevers, were cut ; the country was literally severed into two parts, north and south.

The Effort of Reconstruction

The first objectives of reconstruction, which was undertaken step by step as liberation proceeded, were to re-establish the continuity of the lines and to rehabilitate the rolling stock left.

In spite of the lack of materials and the burden of important priority military traffic, the S.N.C.F. had by December 1, 1944, restored nearly 22,000 miles of line to traffic. Most of the arterial lines had been reinstated and the provisional repair of a number of bridges and viaducts had been carried out. Thanks to these efforts, unprecedented in railway history, traffic was rapidly resumed and in particular coal supplies to the Paris region were ensured during the winter of 1944–45.

This work of restoration was all the more remarkable because hostilities had not finished and the restrictions imposed by warfare were added to those imposed by shortages in every sphere. Not only had the permanent way and bridges to be rebuilt, machinery and trucks repaired, but the needs of the armies marching towards the Rhine and of the civil population had to be met, and that at a time when everything was lacking—steel, coal, cement, fuel oil, bolts, hutments for the accommodation of the workmen engaged on repair work, lorries, telephone circuits, &c. In many districts there was even a lack of a qualified supply of labour.

Thanks to the very able manner in which this task was carried out, the judicious determination of degrees of priority, the vigilance, versatility and ingenuity brought to the operation of traffic, it was possible to satisfy essential needs from the autumn of 1944 onwards. A progressive expansion of services in general at a regularly increasing rate was achieved without too many setbacks.

By the end of 1946 the initial phases of reconstruction had been completed. The length of lines open to traffic was then 25,300 miles, including 2175 miles of electrified lines. Of 2980 miles of track destroyed, more than 2670 miles had been relaid. Of 2603 bridges, viaducts, &c., ruined or damaged, 2460 had been repaired, 1410 of them permanently. Of 70 tunnels blocked, 59 had been cleared. Likewise 11,300 items of track apparatus out of 14,000, the whole of the block signalling system equipment, 500 miles of overhead contact wires out of 600, 36,900 miles of telephone wires out of 41,000, and 608 signalboxes out of 688, had been repaired or replaced. Further, 250 stations out of 960 more or less damaged were repaired, together with three-quarters of the depots, workshops and buildings.

The supply of current on electrified lines was restored on all lines even before the bridges, viaducts, &c., had been restored to service.

As regards the repair and replacement of rolling stock, this could only be effected very gradually owing to the destruction of workshops and depots, to the large-scale removal of equipment by the enemy, and to the shortage of raw materials.

At the present time the continuity of lines has been restored nearly everywhere. Of 2603 rail bridges and 70 tunnels destroyed or damaged at the time of the liberation, 2551 of the former and 66 of the latter had been restored by January 1, 1948. It should be noted that at the same date there were still 623 bridges only temporarily repaired out of the total of 2551.

Nor are the results any less considerable as regards rolling stock. The S.N.C.F. has available to-day :—10,989 steam locomotives in service, of which 9361 are available for use ; 774 electric locomotives, of which 650 are available for use ; 408 electric train motor units, of which 341 are available for use ; 105 diesel locomotives, of which 98 are available for use ; 16,700 passenger coaches and vans available for use ; 311,400 goods trucks available for use.

Finally, with regard to buildings, of the total area of 1074 acres damaged or destroyed, 89 per cent was permanently or temporarily rebuilt by the end of 1947.

Activity of the S.N.C.F. During 1947

Thanks to its accomplishments in the field of reconstruction and its tariff policy, the S.N.C.F. experienced during 1947 an activity greater than at any period preceding the war, in spite of the operating difficulties due to the rolling stock position. Before going into details it must be stressed that the results given below have been obtained with a considerably reduced staff, which fell from 515,000 in number in 1938 to 484,000 in 1947.

These figures bear eloquent testimony to the general increase in efficiency of the railway staff, due undoubtedly to the unrelaxed efforts of the executives and joint committees, but also, and to a great extent, to the pride of profession which is a common characteristic of all railwaymen.

The scarcity of rolling stock compelled the

* Abstracted from a report presented at a Press conference held by Monsieur Marcel Flouret, chairman of the board of directors of the French National Railway Company (Société Nationale des Chemins de Fer Français), on March 16, 1948.

S.N.C.F. to reduce the daily mileage covered by trains before the war, and the average in 1947 did not exceed 230,000 miles during the summer and 190,000 miles during the winter.

In spite of this unfavourable situation, the number of passengers carried and the distance covered by passengers was considerably higher than in 1938, when passengers carried totalled (in thousands) 539,889, compared with 650,590 in 1947, an increase of 20·5 per cent.

In these circumstances it is not surprising that the average loading of trains was much higher than before the war, when the figure was 75 passengers per train for all categories. There has, however, been a distinct improvement in this respect by comparison with the years of occupation, when the average was over 500. It has now been reduced to a figure which during the summer of 1947 varied between 250 and 280.

As regards goods traffic, the number of trucks loaded in 1947 was 13,563,418, which represents a reduction of 12·7 per cent compared with 1938, when the figure was 15,528,500.

Bearing in mind, however, the numerical insufficiency and the age and worn condition of much goods rolling stock, the result was very satisfactory. It was only made possible by a considerable improvement in turn round, the average time between loadings having been reduced from eleven to eight days, thanks to sustained efforts by the staff, to quicker transit times made possible by improvements in the organisation of traffic and to pressure being brought to bear on users to expedite loading and unloading.

A Mobile Concrete Mixer

A NEW mobile concrete mixer, made by Benford, Ltd., of Warwick, is suitable for mixing concrete, mortar, plaster or tarmacadams. Fitted with pneumatic-tyred wheels, independent suspension and override brakes, it can be towed by a moderate sized motor car at high speeds on both roads and rough country with complete stability. At the same time it can easily be handled by one person for manœuvring on a building site.

This mixer is driven by a 1½ h.p. air-cooled Villiers petrol engine, and has an unmixed capacity of 5 cubic feet with a mixed capacity of 3½ cubic feet. Its frame, mixing drum—which pivots through 360 deg.—and the trunnion on which the drum is mounted, are of welded steel construction. The bevel pinion shaft and drum shaft run on large-capacity ball thrust races, and all the gears are effectively guarded. The tilting mechanism is entirely enclosed and the drum gear is covered by steel shrouds.

CONCRETE MIXER ON TOW

It is of about the width of an average car, and the centre of gravity and weight distribution have been carefully studied to ensure stability when being towed. The car-type wheels are mounted on roller bearing hubs and are fitted with pneumatic tyres. Suspension is by independent coil springs. Internal expanding brakes, fitted to both wheels, are operated on the override principle through Bowden cables housed under the frame. The towbar is easily removable—without interference with the braking system—to permit loading, mixing and discharging on either side of the machine.

Retractable, easily operated, stabilising legs provide a firm working base for the machine and two safety legs are fitted to avoid danger of overbalancing during manhandling. Engine repairs can be effected without stripping any other parts of the machine and the chain drive can be adjusted or renewed without disturbing the power unit.

We reproduce a photograph of the new mixer arranged for towing purposes.

Canadian Engineering Notes

St. Lawrence Power

Harnessing of the St. Lawrence River for power purposes moved a step nearer during the third week of July with the submission of plans to the Canadian and United States Governments by the Ontario Hydro-Electric Power Commission and the New York State Power Authority, respectively. In due course, the two Governments will transmit the plans to the International Joint Commission, which, by treaty, has the power to approve them and grant permission to proceed with the development. It is most unlikely that permission will be refused. Estimated cost of the entire project, designed to develop power resources of the river's international rapids section, is more than 391,000,000 dollars. The navigational aspects of the St. Lawrence waterway, which have for so long been a matter of controversy, are not to be included at present in the development, although channels of the present 14ft depth will, of course, be maintained.

The Long Sault Rapids, where the development is to take place, begin about 10 miles west of the city of Cornwall, and continue to within 3 miles of that city. Between the Canadian and American mainland lie several large islands, which will greatly facilitate construction. Under the proposed power priority plan the main features of the undertaking are essentially those which are representative of the power development envisaged in the Controlled Single-Stage project, which formed the basis of the proposed 1941 agreement between Canada and the United States. It is emphasised that the contemplated development is entirely a power project.

Plans provide for a development with a total capacity of 2,200,000 h.p. Among all hydro-electric developments on the American Continent the undertaking is said to be second only in magnitude to the Grand Coulee development on the Columbia River in the United States. Half of the total power output from the natural flow of the St. Lawrence River will be available to Ontario, and, in addition, Ontario will enjoy the benefit of water supplied to the Great Lakes system through the Hydro Commission's Ogoki and Long Lac diversions.

The main dam will be constructed in the Long Sault Rapids, extending from the American mainland shore to the head of Barnhart Island. The closure between the structure and the high ground at both ends is to be secured by heavy earth dykes. The dam will have an overall length of 2900ft. The central portion, 2390ft in length, will be divided into forty 50ft wide openings, by a series of piers, the flow through these openings being controlled by gates on the crest of the dam. This part of the dam will be flanked by bulkhead sections, each with a length of 260ft. The dam will have a maximum height of about 100ft and there will be a roadway, approximately 20ft wide, across the top.

The power-house will be at the lower end of Barnhart Island at the foot of the Long Sault Rapids and astride the International Boundary—one half in New York State and the other half in Ontario. Although the power-house will be a continuous structure, each of the two sections will be complete in itself. The power-house, which will house thirty-six main generator units, will be 3600ft long and will be joined at each end to the high ground by concrete structures and earth dykes. It is estimated that the construction of the power-house alone will require nearly 2,000,000 cubic yards of concrete and approximately 130,000,000 lb of structural and reinforcing steel. Excavation for the power-house and related works is expected to entail the removal of approximately 4,000,000 cubic yards of earth and 225,000 cubic yards of rock.

Extensive channel improvements are required between the head of Galops Island and the town of Morrisburg to reduce the loss in this section of the river and give a higher headwater level at the power-house, and to provide an ice cover for winter operation. Channel excavation below the power-house will lower the tailwater level and increase the head on the plant. Enlargement of the river channels associated with the power development is expected to entail the excavation of about 11,250,000 cubic yards of material, while approximately 1,550,000 cubic yards of concrete and about 6,700,000 yards of compacted earth will be used on other work.

Large areas of land on both sides of the river, approximately 11,360 acres in Ontario and 11,330 acres in New York State, will be flooded by the raised water level, although flooding will be reduced by the construction of dykes. Existing 14ft navigation on the Canadian side will be maintained during the construction of the development, and new locks will be constructed at Cornwall to overcome the concentrated drop in level at this point.

New York Power Authority's portion of the project, in St. Lawrence County, near Massena and Ogdensburg, N.Y., will include the Long Sault concrete gravity dam, a gate-controlled spillway section from the United States bank of the river to the upstream end of Barnhart Island, half of the power-house, dykes for the protection of land along the American side of the river and other facilities. It is estimated that with a normal work programme power could be obtained about five years after the start of construction. The whole development could be completed in about seven years.

Improved "Electric Eye"

An "electric eye" which can see nearly four times as far as present equipment, and which is not adversely affected by outside light, snow or rain, has been developed by the Canadian General Electric Company, Toronto. The new "eye" is claimed to be effective up to 1000ft. Previous devices of this kind, the company states, have been used for distances up to 275ft, the average being 50ft. Included among the applications of the device are the automatic counting of vehicles on highways, operation of traffic signals upon the approach of vehicles, and the "fencing" of restricted areas. When a beam, sent by a light source to a relay, which may be 1000ft away, is broken by any object the relay sets into operation alarms, signals, counters and other electrical equipment. The light source of the new device operates on the modulated light principle. It sends a beam of light that is interrupted 900 times per second. The relay is so tuned that it is responsive only to light at this frequency. Its performance is, therefore, not influenced by changes in natural or artificial illumination.

Industrial and Labour Notes

The T.U.C. Agenda

The final agenda of the eightieth Trades Union Congress, which opens at Margate on Monday next, contains eighty-seven resolutions which have been submitted by affiliated unions. Many of them naturally deal with industrial policy and organisation, and with Government policy as it affects industry.

The Amalgamated Engineering Union, for instance, is putting forward a resolution which expresses concern "at the decline in purchasing power arising from the steadily increasing differences between wages and profits." The T.U.C. is urged "to establish contact with the Government with a view to legislation being introduced for the purpose of restricting profits and controlling prices to prevent devaluation of real wages, and thus enable a higher standard of living to be obtained." Resolutions on very similar lines are also submitted by the Amalgamated Union of Foundry Workers and the Electrical Trades Union.

The Association of Supervisory Staffs, Executives and Technicians, in one of its resolutions, is suggesting that the T.U.C. should create, independently of existing schemes, its own British economic plan, covering not only industry, but all State services. It recommends "a programme of known targets for each section, a co-ordinated wages policy to bring labour to undermanned industries without compulsion, allocation of machinery and raw materials, and import-export agreements with other countries in conformity with the whole." Another resolution from this Association relates to joint consultative machinery. It proposes that the T.U.C., "having arrived at the conclusion that permissive joint consultation in industry has frequently failed," should urge the Government "to make joint consultation committees in industry compulsory in every factory or other production establishment employing twenty-five or more workers." For that purpose, the resolution suggests that a Statutory Instrument be promulgated under the Supplies and Services (extended Purposes) Act. Resolutions on the nationalised industries include one from the National Union of Railwaymen which refers to "the lack of greater recognition given to those with actual day-to-day experience of the operations of industry." The suggestion is then made that the Government should review its policy with the purpose of giving the workers greater participation in the control of those industries now under State control and those nationalised in the future.

There are two resolutions which relate specifically to the nationalisation of the iron and steel industry. The first, from the Amalgamated Union of Foundry Workers, welcomes the assurances on the matter which have been given on behalf of the Government, and then makes the suggestion that "in view of the extreme gravity of the supply position and the urgency of an expanding iron and steel production, an emergency exists which would justify immediate nationalisation by special Government decree." The other resolution comes from the Amalgamated Engineering Union, and draws attention to the shortage of steel which is hampering capital re-equipment, restricting shipbuilding and adversely affecting the building programme. The recommendation is that the Government "should take immediate emergency measures to nationalise the steel industry as a necessary pre-requisite to the rapid reorganisation and expansion of steel production."

British Overseas Trade

In a speech reported on this page of our issue of August 20th, the President of the Board of Trade, Mr. Harold Wilson, indicated that the value of British exports during July amounted to £145,600,000. The accounts issued by the Board of Trade last week show that the actual total was £145,632,342, and that, by volume, July exports were approximately 149 per cent of the 1938 average. The value of imports in July was, at £185,595,078, the highest ever recorded, and re-exports of imported goods were valued at £6,337,959. The adverse visible balance of trade was therefore £33,624,777, which was lower than in any month this year except February, when the figure was £31,200,000.

An analysis of July exports made by the *Board of Trade Journal* reveals that machinery exports reached a new record, and at 86,000 tons were one-sixth above the average for the second quarter of this year. The number of new cars and chassis exported was, at 20,801, slightly below the second quarter average. New ships exported during July aggregated 51,000 gross tons, or nearly double the average in the second quarter. Exports of iron and steel and manufactures thereof amounted to 194,400 tons, compared with a monthly average in 1938 of 159,700 tons. Coal exports showed a further increase during July, and at 1,263,738 tons were 42 per cent of the 1938 average.

The Anglo-American Council on Productivity

The first meeting of the British side of the Anglo-American Council on Productivity was held in London on Wednesday of last week, the principal business being to discuss detailed arrangements for a first joint meeting with the American members. Twelve members have now been appointed to the British side of the Council, six having been nominated by the Federation of British Industries and six by the Trades Union Congress. Sir Norman Kipping, of the F.B.I., and Mr. Vincent Tewson, of the T.U.C., have been appointed joint secretaries.

At last week's meeting terms of reference were formulated, stating that "the purpose of the Council is to exchange views on the question whether there are ways through the European Recovery Programme and otherwise in which United States industry could co-operate in assisting the efforts of British industry to promote greater productivity, and to facilitate any necessary arrangements to that end." Agreement was reached at the meeting upon a general method of procedure to be suggested to the American members as soon as their names are made known.

Apprenticeship Systems in European Countries

In an address delivered recently at a convention in West Virginia, Mr. William F. Patterson, Director of the United States Bureau of Apprenticeship, recommended that the U.S. Government should send representatives from the Bureau to some European countries to act as advisers to governments, and to management and labour with a view to improving industrial relations through apprenticeship. He added the suggestion that an equal number of persons from other countries should be brought to the U.S.A. to study at first hand how the national apprenticeship programme was working.

Mr. Patterson went on to express the belief that his country had developed in the field of apprenticeship a voluntary co-operative approach between management, labour and Government agencies which could be utilised profitably by many European countries. He thought that there was a tendency in some of the European countries he had visited recently of setting up apprenticeship training programmes in terms of Government decree or regulations. In exchanging experiences with employers and unions, Mr. Patterson said he had found that both groups would like to see greater participation by management and labour in working out apprenticeship regulations.

Industrial Rehabilitation

The Ministry of Labour is circulating a leaflet which gives some up-to-date information concerning the objects of the industrial rehabilitation centres which it has now established in various parts of the country. The aim of the centres, of course, is to discover, in a practical way, how disability affects working capacity, and also to assist disabled persons to be guided into new types of work, if necessary. In addition, the centres are also available to assist persons who are not disabled, but who have been unemployed for a lengthy period and have lost confidence.

The courses provided at the centres do not lay down a hard and fast curriculum for everybody taking them, but are adjusted to meet the needs of the individual. The primary consideration, it is stated, is to make everyone fit, or as fit as his disability will allow, and specialist officers are available to advise on suitable forms of employment, and on local employment prospects, or to give advice and assistance on personal problems.

The leaflet includes particulars of the allowances which are payable during the courses.

Scrap from Germany

The tenth report from the House of Commons Select Committee on Estimates (H.M. Stationery Office, price 4d.) includes, as an appendix, the observations of the Ministry of Supply on matters relating to the purchase and collection of iron and steel scrap in Germany. It will be recalled that in March last the Ministry set up a Scrap Investigation Committee under the chairmanship of Sir Graham Cunningham.

In its report, that Committee has noted that the Disposals Group of the Control Commission for Germany includes among its functions the task of removing booty scrap and delivering it to the loading port. The Scrap Export Agency of Iron and Steel Disposals, Ltd., is responsible for shipping all scrap from Germany to the United Kingdom, and since the Disposals Group has not the necessary personnel for supervising the cutting and removal of booty scrap from its original site, as well as loading and shipping it at the ports, the Scrap Export Agency has largely assumed responsibility for the task. The Cunningham Committee does not consider that such a division of responsibility is an ideal arrangement, but thinks that the two organisations co-operate very closely and, within the limitations imposed by difficulties in the supply of labour, transport and equipment, are doing good work. Lieut.-General Sir Kenneth Loch, a member of the Scrap Investigation Committee, has now been appointed by the Foreign Office as scrap co-ordinating officer in Germany. He is to be responsible for co-ordinating and progressing all matters concerning the procurement of all scrap, booty and commercial, for the United Kingdom, and for recommending changes in the organisations charged with the procurement of ferrous scrap in order to ensure that they are adequate to their tasks.

The Ministry of Supply says that loading facilities at the ports have been greatly improved, and that, following the recommendations of the Scrap Investigation Committee, a large number of cranes and other equipment have been made available for scrap operations in Germany during the last few weeks. On the subject of supplies and transport, the Ministry states that there is normally sufficient tonnage available on the open market to meet shipping requirements up to 80,000 tons a month. Monthly shipments of scrap from Germany are now approaching that total, and may shortly be expected to increase to 100,000 tons a month; but there is no immediate prospect, the Ministry adds, of scrap supplies reaching the figure of 120,000 tons a month which was thought probable some time ago. The transport branch of the Ministry is said to be fully alive to the situation, and the report observes that there is no reason to suppose that sufficient shipping will not be available to cope with all demands likely to be made in the foreseeable future. It will be part of General Loch's duty to satisfy himself that adequate facilities exist, or can be made available, to ship the maximum quantities of scrap likely to come forward.

French Engineering News

(From our French Correspondent)

Work has begun on the construction of a Steel Research Institute owned jointly by the Chambre Syndicale de la Sidérurgie and the Chambre Syndicale des Aciers Fins et Speciaux. The new laboratories will comprise two large buildings, one for the heavy workshops and technological laboratories, and the second for pure science laboratories.

In addition to the new buildings, the Institute already has an ore-testing station at Saulnes and an office to follow studies on coke and blast-furnaces at Longwy.

Until the new laboratories are ready the research workers and engineers of the Institute will use other factory and university laboratories at home and abroad.

* * *

There has been a categoric denial by the Ministry of Foreign Affairs that a mixed Franco-American consultative committee for the technical co-operation of the two countries has been formed. A Franco-American industrial liaison committee has existed for some months, however; its main aim is to send French technicians to America to study American production conditions.

* * *

Out of the 320 locomotives being converted to oil-firing by the S.N.C.F., forty-seven have been equipped by the Niort workshops and seventy-two at Nevers. The work, which was slowed down by lack of steel plate, pumps and piping, has now resumed its schedule. The work was undertaken at the request of the government in order to save coal, and the S.N.C.F. has now been able to state that tests show that burning fuel oil does not affect fireboxes any more than coal and that the cost is similar.

* * *

The Fives-Lille Company annual report shows that activity is now greater than in 1938, thanks to an influx of foreign workers. Modern machine tools and material is already working, including an electric oven for the foundry, which is expected to increase and improve production. In the course of 1947 the company's engineers travelled to Egypt, Madagascar, Reunion, South Africa, Maurice Isle, South America and the Antilles. Despite economic conditions and French prices, these missions have maintained France's position in world markets by demonstrating the excellence of materials shown. Orders placed in 1947 were particularly satisfactory and included shunting locomotives for the national mines, important equipment for steel works and coking ovens, air compressors, special travelling cranes, hydraulic turbines, including a 90,000 h.p. turbine for Génissiat and four 70,000 h.p. turbines for Donzères-Mondragon, electrical equipment, boilers, plant for cement works, &c., as well as locomotives for the S.N.C.F.

* * *

The relative values of theory and practice in the training of an engineer were discussed recently in connection with the National Education budget. Monsieur Finet, while recognising the necessity for scientific teaching, felt that practical experience was at least as important. Too often, he said, the engineer was confused with a draughtsman, whereas, with the breadth of his scientific knowledge he should be capable of translating theoretical and abstract formulæ into practical work. He expressed fears that instruction given was often too theoretical and removed from practical reality. He also asked that too early specialisation should be avoided, and that a Directorate of Higher Technical Education should be organised. The first task of such a directorate should be to determine programmes, co-ordinate them and establish the requirements in qualified men needed by the country.

* * *

Steel production for July shows that in all branches 1938 figures have been passed, although only by very little for Martin steel. Thomas steel production exceeds that of Martin steel at the moment owing to improved coke supplies.

Notes and Memoranda

Rail and Road

INSTITUTION OF HIGHWAY ENGINEERS.—H.R.H. The Duke of Edinburgh has accepted honorary membership of the Institution of Highway Engineers.

STEPHENSON CENTENARY.—In the four days August 12th to 15th inclusive, 38,221 people visited the British Railways Exhibition at Chesterfield, held to commemorate the centenary of the death of George Stephenson.

LEYLAND AUTOMOTIVE AND INDUSTRIAL UNITS.—Leyland Motors, Ltd., has created a new organisation to be known as the Automotive and Industrial Units Division. Its purpose is to deal with the design, production and marketing of power plants, transmission and other ancillary units based on standard Leyland products. Mr. V. W. Pilkington is taking full charge of the new organisation.

BRITISH TRANSPORT TRAFFIC RECEIPTS.—The British Transport Commission reports that in the four weeks ended August 8th traffic receipts on British Railways amounted to £28,276,000. Receipts in the corresponding period of 1947 were £25,492,000, but it must be borne in mind that since then there have been increases in railway fares, rates and charges. London Transport receipts in the four week period ended August 8th were £4,555,000, and tolls and freight charges on inland waterways totalled £121,000.

Air and Water

SWEDEN'S MERCHANT NAVY.—At the end of June, the Swedish Merchant Navy consisted of 2151 vessels aggregating 1,966,943 gross tons. Total additions to the fleet during June were six ships, aggregating 14,197 gross tons.

P. AND O. LINER "MOOLTAN."—It is stated that the 21,000 ton P. and O. liner "Mooltan" has completed her trials following reconditioning in the Belfast yard of Harland and Wolff, Ltd. She was expected to leave London this week for Australia, carrying 1030 tourist class passengers.

LONDON AIRPORT.—The first of a series of booklets of Britain's airports has been produced by the Ministry of Civil Aviation and the Central Office of Information, and is entitled "London Airport." It deals with the construction and the equipment of London Airport, gives some particulars of the various types of aircraft which use it, and includes also some useful information on the methods of handling passenger and freight traffic. "London Airport," which is fully illustrated, is published by H.M. Stationery Office at 1s.

DE HAVILLAND AERO-ENGINE SERVICE.—The de Havilland engine service department has announced a new engine-replacement service of interest to operators of Gipsy engines of types no longer in production but still in use all over the world. The scheme is an extension of one which has been in operation for some months for the Gipsy Queen series 70 engine. The same service will now include all engines of the Gipsy Major 1 series and the later versions of the Gipsy Six series, now known as the Gipsy Queen 2 and 3. Operators may notify the company when an engine of any of these types is approaching the time for a complete overhaul, and arrangements will then be made for an overhauled engine of the same mark to be ready as immediate replacement for the time-expired unit. The replacement engine carries the same warranty as is given by the company, as manufacturers, with each new engine.

"MAMBA" TURBO-PROPELLER ENGINE TEST.—We learn that 500 hours of sealed running has been completed on the Armstrong-Siddeley "Mamba" engine without anything more than minor servicing. It is computed that had this engine been in an aeroplane the distance flown would have been 150,000 miles. The test was officially carried out under the supervision and control of the Air Registration Board. The total of 500 hours comprised thirty-four periods of five hours' duration and thirty-three periods of ten hours' duration. Each five-hour period consisted of:

	Minutes
Initial starts, idling, taxying and acceleration	18
Maximum take-off	3
Maximum cruise	30
70 per cent take-off power	60
65 per cent take-off power	60
60 per cent take-off power	60
58 per cent take-off power	60
Final accelerations, taxying, &c.	9

Each ten-hour period consisted of two of the above periods.

Miscellanea

SOCIETY OF INVENTORS' EXHIBITION.—The second annual exhibition to be organised by the Society of Inventors will be held at the Chamber of Commerce Buildings, Birmingham, from October 25th to 30th. The exhibition will give manufacturers an opportunity to examine new ideas and meet inventors personally and also to exhibit prototypes to test public demand. Entries for the exhibition may be made by members and non-members, and details may be obtained from Mr. J. E. Wilson, Trent Valley House, Lichfield.

U.K. TIN STATISTICS.—The Ministry of Supply announces that existing arrangements for the publication of United Kingdom tin statistics are being changed. Full information will henceforth be available in the monthly *Bulletin* of the British Bureau of Non-Ferrous Metal Statistics and in the monthly *Statistical Bulletin* of the International Tin Study Group. The statistics in question are the monthly United Kingdom tin statistics and the quarterly figures for tin consumption by main trades incorporated in the quarterly statistics of non-ferrous metals. The Ministry will continue to announce details of international tin allocations and of official prices for tin.

THE LATE MR. D. G. WILLIAMS.—We have learned with regret of the death of Mr. Denzil George Williams, which occurred as the result of a bathing accident at Bude on August 24th. He was chief draughtsman at the Causeway Works, Staines, of Associated British Oil Engines, Ltd. Mr. Williams was born at Swansea in 1897 and served his apprenticeship under the late Mr. John Henry Hamilton at the Premier Gas Engine Company, Ltd., Sandiacre. He entered the drawing office of Petters, Ltd., in 1927, and was appointed chief draughtsman ten years later. He was a member of the Institution of Mechanical Engineers and of the Institute of Marine Engineers.

EXHIBITION OF ELECTRONIC INSTRUMENTS.—An exhibition of electronic instruments for use in industry and research will be held at the Grand Hotel, Birmingham, from September 20th to 24th inclusive. The exhibition will be open from 10 a.m. to 6 p.m. daily, and admission, which is free, will be limited to ticket holders only. Further information and tickets will be supplied to the trade on application to Cinema-Television, Ltd., Worsley Bridge Road, Lower Sydenham, London, S.E.26. Among the instruments to be shown is an electronic metal detector for detecting tramp metal in raw material and in manufactured goods before they leave the factories. An electronic counter will also be exhibited, which, counting at speeds of up to 30,000 per minute, can record the output of machines, or can be used in research work to count radiation particles.

A WORKS EXHIBITION OF LARGE MACHINE TOOLS.—We are informed that as Craven Brothers (Manchester), Ltd., Reddish, near Stockport, is not exhibiting at the Machine Tool and Engineering Exhibition at Olympia, special arrangements have been made to receive visitors from home and abroad in the works during the period August 26th to September 11th. Here about fifteen typical "Craven" machine tools are being demonstrated at work. The exhibits include lathes up to 55in centres, railway wheel lathes, a large vertical boring and turning mill, worm thread milling and grinding machines, a heavy-duty roll turning lathe and wobbler end milling machine, a universal gear-hobbing machine, and several special railway machine tools. In addition, there are many other machine tools to be seen in various stages of erection, and visitors are able to make a tour of the workshops.

LECTURES IN CONCRETE TECHNOLOGY.—By arrangement with the Reinforced Concrete Association a course of instruction in concrete technology will be given at the Westminster Technical College during the 1948–9 session. The course will include lectures and laboratory instruction in the properties of concrete and its constituent materials; the design of concrete mixes and the proportioning, mixing, placing, consolidation and curing of concrete; the principles of reinforcement and the use of formwork. The syllabus has been drawn up primarily to meet the requirements of resident engineers, foremen, clerks of works, and others engaged on constructional work, and will include visits to works. The lecturer will be Mr. E. H. Collier, A.M.I.C.E., and further particulars may be obtained from the Head of the Engineering Department, Westminster Technical College, Vincent Square, London, S.W.1, or from the Reinforced Concrete Association, 94–98, Petty France, London, S.W.1.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Special Libraries (Aslib)

Friday to Sunday, Sept. 17th to 19th.—Ashorne Hill, near Leamington Spa. Annual conference.

British Association

Wednesday to Wednesday, Sept. 8th to 15th.—Annual meeting at Brighton.

Gauge and Tool Makers' Association

Tuesday, Sept. 14th.—Savoy Hotel, London, W.C.2. Quarterly Luncheon. 12.30 for 1 p.m.

Incorporated Plant Engineers

To-day, Sept. 3rd.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham. "Feed Water," W. Murray. 7.30 p.m.

Thursday, Sept. 9th.—NEWCASTLE-UPON-TYNE BRANCH: Y.M.C.A., Connaught Rooms, Blackett Street, Newcastle-upon-Tyne. "Diesel Engines," E. Hill. 7.30 p.m.

Tuesday, Sept. 14th.—EAST LANCS BRANCH: Engineers, Club, Albert Square, Manchester. Films by Stewarts and Lloyds, Ltd., "Pluto" and "Through the Mill." 7.15 p.m.

Thursday, Sept. 16th.—LIVERPOOL AND N. WALES BRANCH: Liverpool Engineering Society, 9, The Temple, Dale Street, Liverpool. Business Meeting. 7.30 p.m.

Tuesday, Sept. 21st.—GLASGOW BRANCH: Engineering Centre, 351, Sauchiehall Street, Glasgow. "Power Transmission Problems and the Use of Suitable Couplings," C. W. Chapman. 7 p.m.

Thursday, Sept. 23rd.—SOUTH YORKS BRANCH: Grand Hotel, Sheffield. "High Pressure Lubrication," F. Maxwell. 7.30 p.m.

Tuesday, Sept. 28th.—S. WALES BRANCH: South Wales Institute of Engineers, Park Place, Cardiff. Inaugural Meeting. 7.30 p.m.

Thursday to Saturday, Oct. 7th to 9th.—First annual conference at Cheltenham.

Institution of Electrical Engineers

Friday, Saturday and Sunday, Sept. 10th, 11th and 12th.—TRANSMISSION SECTION: Summer Visit to Buxton.

Institution of Heating and Ventilating Engineers

Wednesday, Sept. 29th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. "Research for the Heating, Ventilating and Air Conditioning Engineer," Cyril Tasker. 6 p.m.

Institution of Naval Architects

Tuesday to Friday, Sept. 21st to 24th.—Autumn meeting in London.

Institution of Production Engineers

Tuesday, Sept. 7th.—COVENTRY GRADUATES' SECTION: Room A.5, Technical College, Coventry. "Automatic Turning Machines," R. F. Eaton. 7.15 p.m.

Thursday, Sept. 9th.—WOLVERHAMPTON GRADUATE SECTION: County Technical College, Wednesbury. "Foundry Practice," E. L. Graham. 7.15 p.m.—GLASGOW SECTION: Visit to the works of Anderson Boyes and Co., Ltd., Flemington Electrical Works, Motherwell. 6.30 p.m.

Monday, Sept. 13th.—MANCHESTER GRADUATE SECTION: Reynolds Hall, College of Technology, Manchester. "The Lost Wax Process," A. P. Short. 7.15 p.m.

Tuesday, Sept. 14th.—BIRMINGHAM GRADUATE SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham. Film evening, "The Romance of Carborundum," 7 p.m.

Thursday, Friday and Saturday, Sept. 23rd, 24th and 25th.—First National Convention, 1948, Bournemouth.

Machine Tool and Engineering Exhibition

To-day to Saturday, Sept. 11th.—Olympia, London. 10.30 a.m. daily (except Sundays).

CENSUS OF DISTRIBUTION ADVISORY COMMITTEE.—Early in July the President of the Board of Trade appointed the Census of Distribution Advisory Committee to advise on the preparation of the forms and instructions necessary for the taking of the first National Census of the distributive and service trades, covering trading in the year 1949. At its first meeting the Committee decided that, in view of the special problems associated with the wholesale trades, a sub-committee, drawn from the various branches of those trades, should be set up to consider and make recommendations upon the forms to be issued to firms engaged in them. This sub-committee has now been constituted under the chairmanship of Mr. J. Stafford, Director of Statistics to the Board of Trade.

Personal and Business

MR. G. C. HANDLEY has been appointed industrial sales manager of Worthington-Simpson, Ltd.

MR. S. F. WISE has been appointed controller of purchasing and stores, Baker Perkins, Ltd., Peterborough.

THE MINISTRY OF TRANSPORT announces the appointment of Mr. W. F. Quin as Regional Transport Commissioner for the Scottish Region.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that its Edinburgh branch office has been moved to 80–82, Hanover Street, Edinburgh.

THE LEYTONSTONE JIG AND TOOL COMPANY, Ltd., has opened an office at 31, Willcocks Street, Toronto, 5, Canada. Air Vice-Marshal D. F. Stevenson, C.B., is the resident director.

THE BOARD OF TRADE states that from September 13th the headquarters of the Export Licensing Branch will be at Regis House, King William Street, London, E.C.4 (telephone, Avenue 3111).

THE RAILWAY EXECUTIVE announces the appointment of Mr. S. H. Fisher as deputy chief regional officer, London Midland Region, in succession to Mr. T. W. Royle, who will retire on September 30th.

MACROME, Ltd., announces the appointment of the following agents:—West African Engineering Company, Ltd., P.O. Box 8, Sekondi, Gold Coast Colony; The British Italian Trading Company, Ltd., 75, Bishopsgate, London, E.C.2; and Nielsen and Danielsen A/S, Tollbodgt 25, Oslo, Norway.

Technical Reports

Road Research Technical Paper No. 10: "A Review of Available Information on the Significance of Roadstone Tests." H.M. Stationery Office. Price 6d.—A number of standard tests for roadstones have been developed and attempts have been made to relate the values obtained from the test to the observed performance of the structures or surfacings in which the stones are utilised. Unfortunately, the properties required for different purposes and the inherent properties of the stones themselves vary so greatly that the attempts to obtain correlation have so far only been partially successful; such information as is available is scattered among a number of papers, each dealing with a particular aspect, and many of them in comparatively inaccessible journals. In this paper the Road Research Laboratory, D.S.I.R., has summarised the main conclusions from all these papers, together with some hitherto unpublished information.

The reproducibility of the results of repeat tests on the same sample is considered, as this determines whether or not a test can be relied on to give a true measure of the quality of the aggregate. It is shown that some of the older tests—especially those carried out on small, single pieces of stone—have very poor reproducibility, whilst that of the newer tests, carried out on quantities of the aggregate, is good.

The paper shows that much work remains to be done before specification limits can be based on test results. The available information is, however, considered to be sufficient to justify the adoption of approximate lower limits of crushing strength, &c., as a general guide in the selection of aggregates for waterbound, concrete and bituminous roads.

National Building Studies: Special Report No. 1, Structural Requirements for Houses. H.M. Stationery Office. Price 9d.—Many of the new types of houses were submitted to the Interdepartmental Committee on House Construction (usually known as the Burt Committee) for consideration. In order to help the Committee in its judgment of these types, the Building Research Station, D.S.I.R. made many loading tests on the full-scale structures. As far as possible the tests were standardised in order to simplify their application and to obtain a common measure of the properties of various types of structure. The Report gives the figures for all the various loadings such as floor and roof loadings, snow and wind loadings, &c. It is well supplied with photographs to indicate the tests undertaken. The strength of houses has received little attention in the past. In the traditional brick or stone house, the thicknesses of the walls were controlled by the degree of weather resistance or thermal insulation required, and these thicknesses were ample for the loads supported by the walls. With present-day knowledge of the insulation and weather protection given by building materials, and with the development of structural frameworks, it is possible to design houses which satisfy all functional requirements, but which have a strength of less than that of the traditional house. The various types of pre-fabricated houses are in this class. Since an unnecessarily high strength is wasteful of materials and increases the cost of construction, it became important to decide what are the minimum structural requirements that need to be fulfilled.

Contracts

CROSSLEY MOTORS, Ltd., has received a repeat order from Birmingham City Transport for 200 double-deck omnibuses. Both chassis and bodies will be produced throughout in the Crossley factory at Manchester.

THE ENGLISH ELECTRIC COMPANY, Ltd., has received an order from the Hydro-Electric Power Commission of Ontario for two 60,000-kW turbo-alternators. The sets will run at 3600 r.p.m. and the alternators will generate at 13,800V, 60 cycles. Steam conditions at the turbine stop valves are 850 lb per square inch and 900 deg. Fah. The turbines are of the two-cylinder, impulse-reaction type.

SIMON-CARVES, Ltd., has received an order for coal-cleaning and carbonising plant at Vryheid Coronation Colliery, in the Transvaal, for the Anglo-American Corporation of South Africa, Ltd. The value of the work involved is approximately £1,250,000. Coal will be cleaned at the rate of 175 tons per hour in a Simon-Carves "Baum" type washery and will be carbonised in 184 "Underjet" ovens of the waste heat type with a coking capacity of 1600 tons of coal per day. The coke ovens will be in two batteries of ninety-two ovens each, complete with coal receiving, crushing and handling plant, coke quenching and screening equipment, waste heat boilers and gas cleaning plant.

VICKERS-ARMSTRONGS, Ltd., has received an order for low-lift pumps, gears and electrical equipment from the Ministry of Public Works, Buenos Aires. The plant is to be installed in Balneario pumping station on the River Plate. The contract includes the supply and erection of two 84in diameter pumps, inclined at an angle of 45 deg., driven through reduction gearing by 750 h.p. electric motors, complete with control gear, weed screens with motor-driven raking gear and other ancillary equipment. Each pump is capable of dealing with 12·4 cubic metres per second (164,000 gallons per minute) against a total head of 3·5m, the manometric efficiency being nearly 90 per cent.

Reports on German and Japanese Industry

Limited numbers of copies of the reports of Intelligence Objectives Sub-Committees on German and Japanese Industry listed below can be obtained from H.M. Stationery Office at the prices stated.

No. of report	Title	Post free s. d.
B.I.O.S.:		
1714 ... ... (in 2 parts)	Electrical Aspects of Buna, with Some Notes on Other Dielectrics	70 5
1716	The German Electrical Indicating Instrument Industry—its Technique and Materials	25 4
1717	Report on German Work Relevant to the Interaction Between Tyres, Vehicles and Road Surfaces	9 3
1762	German Electro-Technical Ceramics	4 8
1765	German Fire Services	7 2
1782	Further Aspects of the Manufacture of Egg and Albumen Substitutes	1 1
Classified List—		
No. 18 ...	Consolidated list under subject headings of all reports on German and Japanese industry published up to and including March 31, 1948. (This list supersedes all previous lists and supplements.)	1 3
Technical Index—		
(Part 1) ...	Alphabetical subject index of reports on German industry published up to and including July 27, 1946	5 3
(Part 2)) ...	August, September and October, 1946, supplement to the above index	1 7
(Part 3) ...	November and December, 1946, supplement to the above index	1 7
(Part 4) ...	January, February and March, 1947, supplement to the above index	2 2
(Part 5) ...	April/September, 1947, supplement to the above index	3 8

Technical Information and Documents Unit, German Division, Board of Trade, 40, Cadogan Square, S.W.1, which has at its disposal a considerable volume of information not in a form suitable for general reproduction, is prepared to receive enquiries regarding all problems relating to scientific and technical intelligence on both German and Japanese industry.